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THE

MECHANIC'S TOOL BOOK.

WITH

PRACTICAL RULES AND SUGGESTIONS

FOR USE OF

MACHINISTS, IRON-WORKERS,

AND OTHERS.

BY W. B. HARRISON,

Associate Editor of the "American Artisan."

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PREFACE.

It is an old saying that "no two mechanics work alike;" and it needs but a slight observance of the different modes of working to verify the truth of this proverb. One man will handle his files, hammer, and gauges as if "to the *manner* born," while others are unhandy and awkward, and will always be so no matter how long they may work at their calling. Some mechanics are remarkable to originate and adapt tools to various purposes, while others can copy after the experts only in a very bungling manner. In many shops, particularly the jobbing machine-shop, a readiness to adapt with celerity whatever tools there are for the purpose intended to be effected, is a rare and valuable quality in mechanics, and such men are not to be easily found. When once having seen an operation it is very easy to "go and do likewise," and it is for the benefit of those who can copy but not originate methods of working that we propose to embody in this book the experience of a mechanic as compiled in a series of commonplace notes, well knowing that some of the items and descriptions are simple and perhaps well known to many; yet there may be some who have not the benefit of even this simple knowledge, and to them we hope to give occasional hints that may be of practical use and benefit.

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CARE OF TOOLS.

As regards the general care of tools, it cannot be too strongly enjoined on the mechanic, and particularly the iron-worker, to keep his tools neat, clean, and in order. To the observer this gives the mechanic an appearance of being a good workman when perhaps he has only medium skill. To the initiated a "workman is known by the chips he makes;" to the uninitiated an idea that the operator is a good workman may be conveyed by the appearance of the tools he sees the workman using. If screw-taps and dies are gummed up with a poor quality of oil and dirt, and covered with a hardened layer of some oleaginous compound; if hammers are rusty and with faces covered with careless nicks and fitted with ill-shaped and broken handles; if scribers are blunt and badly ground, or perhaps the shank of an old file used for this instrument; if cold-chisels are made very much like old shanks taken at random from the scrap-pile, and litter, dirt, tools and fragments are clustered together in a close agglomeration, it will convey about the same idea to the observer that a beggar in tattered habiliments would in the parlor of a prince. Every one would feel a great desire to either eject the intruder from the apartment or at once leave the place himself. We give this as the first hint of instruction to mechanics, and particularly the young mechanic who is just commencing his sphere of future usefulness: see that your tools are made in a neat and workmanlike manner, and cultivate order in the arrangement of them upon the bench or their place of deposit. If, upon entering a machine-shop, we see the tools scattered in confusion upon the workbench, where they are usually deposited, and observe that they are rusty and dirty, and mingled with the *debris* which will collect around the vise, and that portions of work upon which the mechanic is engaged are indiscriminately piled around and upon his tools, we soon feel distrust of any very great ability of the workman, although he may prove expert in his occupation.

We have seen mechanics work in a manner that plainly indicated that they cared little whether they had proper tools or not; and the impression produced was that some workmen care as little for the reputation of the product of their labors as they do about their tools. If we examine the tools of such mechanics, we find that the hammer-faces are full of nicks and dents, and the handles are battered and badly shaped, and that the gauges and more delicate tools are as ill-kept as the hammers; and it may be taken for granted that the work of such men generally corresponds with their tools.

In addition to keeping tools neat and in order, the mechanic ought to really *love* his tools and regard them with a kind of pride—the same as the sailor feels proud of the ship in which he sails, and the artilleryman values the gun which he "serves." But so often do we see the opposite of this spirit, that affection for tools may be considered the exception rather than the rule; and instead of a care being exercised to keep tools as they ought to be kept, they are thrown about like old iron. Instead of laying them carefully aside when the hours of labor cease, we see them left scattered upon the work-bench or thrown carelessly into the drawer, and the files, chisels, reamers, squares and straight-edges are mingled in confusion, bruising, indenting, and injuring each other.

Perhaps these mechanics feel interest enough in their labor to purchase the necessary hand tools, such as gauges, callipers, fitting squares, etc.; but we often find workmen with no tools, and when engaged upon their work they manage to "get along" without tools, or they borrow those of some brother mechanic whose vise or place of operations is in their immediate vicinity.

All the small bench or hand tools that we have mentioned, which are generally used upon all kinds of work, ought to belong to the mechanic who uses them; and if he does not possess them, and his means will not allow him to purchase a full set of first class-instruments, and he hesitates between a few good ones or many of a poorer quality, we say, unhesitatingly, that he ought to choose the former, and add to the supply as his means may increase. A set of *good* tools will last for a lifetime, while a set of poor tools can at no time be relied upon for exactness, and soon become worn out.

A mechanic ought to make all the small tools which he is capable of making; and these can be completed at odd hours, or in the intervals of work when he would be idle, as at morning, noon, and night; and in a short time he will be in possession of many tools of a better quality than those he can purchase at the hardware stores. The material for these tools will cost but a trifle, and can be easily obtained. Work upon such tools should not be performed in a hurried or careless manner; but should be done in a careful and workmanlike style; and then the mechanic will have samples of his skill and efficiency of which he will not be ashamed; and if at any time he be called upon for reference as to his mechanical ability, he can exhibit those tools as a proof of expertness.

Manufacturers very much dislike to see their operatives "tinkering" over tools and in many cases it is of no use to allow it, while in others a little stimulant in this direction will be of advantage to both mechanic and employer. A liberal-minded employer would not object to his operative using a few shillings' worth of stock to make a few tools in his leisure moments which are to be used in the production of manufactured articles for the employer, nor would an honest-minded mechanic take the time belonging to his employer for the manufacture of the tools he intends to be considered his own private property.

FILES AND FILING.

As the file is a tool of universal use among many classes of mechanics, and more especially those who work in iron, it may be well to give a few hints to those who are not thoroughly initiated in its use. Of the diversity of files and their adaptability to different processes we will say nothing, supposing that to be sufficiently understood.

The work to be filed should be elevated in the vise or fastened by some means at a hight a little below the elbow as the operator stands erect. The reason of this is obvious. As the file-handle is grasped in the right hand and the point of the file in the left hand, the arms can hang in a more natural position, and as the file is thrust forward and brought back for a repetition of the thrust, the movement is made in a horizontal line with greater facility than if the elbows were required to be raised to make the stroke of the file in the line parallel with the line of the work. The file has not the guide principle as the carpenter's plane has, and the movement of the file must be accomplished by the position and movement of the elbow. The most natural movement of the hand and elbow are in circular lines, the joints of the limbs being the centre of motion, but in filing a flat surface the hands must be trained to move in right lines.

The mechanic should select good, well-proportioned handles for his files; disdain everything that pretends to be "fancy." Handles are best made of well-seasoned maple with strong brass or iron ferrules. The file shank ought to be inserted into the handle in which it is held nearly the entire length of the shank. The handles as purchased, are usually bored with a hole for the reception of the file shank, but when they are not so bored the mechanic is necessitated to do it himself. If a small gimblet or bit be used to bore with, it is essential to observe that it enters the handle at the exact center of the circumference of the ferrule, and that the hole is kept true and central in the handle as the bit advances. This can be ascertained by letting the handle turn in the hand as the boring progresses, the hold of the bit upon the wood being sufficient to admit of its so doing. As the file shank is made of a taper form, it is quite necessary that the hole in the handle be made to correspond, and a taper reamer will form it accurate enough to receive the shank. Do not let a file shank be inserted in the handle up to the shoulder of the file; for it will soon become loose and the shank will no longer *wedge* into the wood, but if a space of about one-half or three-fourths of an inch be between the handle and the file shoulders, no immediate apprehensions of looseness need be anticipated.

Some mechanics heat the shank of an old file, and with it burn into the handle to shape a place for the reception of the file shank, but such a practice betokens a slovenish workman and is very detrimental to the wear of the handle, for by the wood being charred in the process of burning, it is rendered very brittle, and the handle soon splits with even ordinary usage and must then be thrown away. If the mechanic seeks to retain the split handle, or mends it by inserting a screw or winding it with wire or cord so as to make it subservient to his purpose, it has a botched and unsightly appearance, and is a very unsatisfactory handle after all.

We have seen on a workman's bench two dozen or more files of different sizes, and used for different kinds of work, and with each kind or size of file there was a handle wholly differing from its fellows. We might enumerate that we observed in this lot of files one or two passable handles, one or two chisel handles, two or three which were designed for the awls of shoemakers, some made from pieces of a broken broom-stick, as many taken from a rough limb, denuded of its bark, one or two whittled from a pine stick, the product of the pocket-knife of the apprentice, and thrown away by him as useless, and—not a new application—some of the handles were actually formed of corncobs. It might be that a workman would produce as good work with file handles of this character as with well-turned and good-ferruled ones, but where the latter are employed it gives a neater look to the bench; and certainly the workman will operate as expeditiously and as well with *good* tool appliances as with poor ones. If the expert or apprentice would cultivate a disposition for neatness and exactness in his work, he may begin with his tools and appliances, and his file and other handles are very good things to commence with.

If a file-handle becomes split or broken, throw it aside and replace it with another. Do not use pieces of a broom-handle, or bits of small limbs denuded of their bark, as we often see done; files *botched* up in this way have a sorry appearance and give the look of a "slouchy" workman. Use handles appropriate and proportioned to the tools for which they are intended, take time and care to fit them properly, and experience will testify that they will give better results and last longer, proving that "haste makes waste" even in the small matter of fitting a file handle.

Learn to keep your filing-vise clean and files in a neat row beside the vise according to their respective sizes. When you begin to use a set of new files mark one side of them with white chalk, reserving the chalked side to finish any nice piece of work with where a sharp file is wanted. Always have a set of files for the different kinds of metals you work upon. When files do not cut brass with facility, they may then be employed to cut cast-iron, wrought-iron, and, lastly, steel; but if put upon steel or iron first, they are worthless for cutting brass. The surface-scale of metals, particularly cast-iron, should be removed before a good file is put upon it, as this scale will instantly destroy the cutting-edge of the file-teeth. It is equally injurious to files to admit of pressure on the file when it is being drawn back for the forward thrust; good filers always raise the file from contact with the work when they draw it back, and lay it gently upon the surface to ensure the correct position, and then apply the needful force to make the cutting-thrust.

In the finishing of the bright-work of tools and machinery two methods of filing are employed:—polishing and draw-filing. The former method was at one time very prevalent, but of late years, especially upon heavy machinery, has been discarded, and a finish by the latter method adopted. To the uninitiated and ignorant the glare produced by polishing is paramount as a finish, but the educated mechanic views it with as much disdain as the enlightened mind regards the sham baubles that please the eye of an aborigine. Polishing, as compared with the process of draw-filing, is a cheap method of finishing-up tools and machinery, and as a general thing it is only the cheaper class of machine-work that is thus finished, and a piece of mechanism which is glistening from the application of polishing-wheels is open to suspicion as work of inferior merit.

Some labor as well as skill is required to produce a well draw-filed surface, while almost any cheap labor will suffice to operate a polishing apparatus. Patience in the former method rewards us with an exterior which is soon learned to be appreciated, and the mechanic who produced it will look upon his work with evident satisfaction. On observing a mechanic at work and seeing him place his file transversely across the piece of metal upon which he is operating, and then grasp it at each end and move it over the surface to be finished, the operation seems very simple and one which any one can perform ; but let the tyro try to do it and he will find that the finish which he produces is quite different from what he attempts to accomplish. Instead of the clean, smooth dead surface, containing thousands of minute parallel lines formed by the action of the file-teeth, he will find that his finished surface is full of crossed lines, and marred at frequent intervals by little ragged scratches which he can scarcely account for. To avoid the crossing of these minute lines practice to carry the hands over the work in the same parallel lines is requisite, and to avoid scratches requires a delicacy of touch and feeling not so easily acquired, but which instantly tells the mechanic when any foreign matter or filings remain interposed between the file and the work, and which if not removed produce injury that will take some time to eradicate.

To the educated mechanical eye there is no finer finish than that of draw-filing. Small tools and machinery, like sewing machines and jeweler's tools, it may be advisable to polish, but for larger work, such as lathes and engines, the file finish is far preferable.

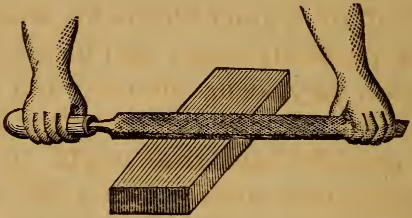

Fig. 1.

Draw-filing is done by holding the file in a transverse line with the work, and then drawing it back and forth over the surface to be operated upon. Work finished in this way has a very neat finish and appearance. To clean the files when clogged with the *debris* of the work, use a wire brush or a thin piece of sheet-brass which may be drawn through the cut of the teeth, and it will effectually clean them; a better instrument is a piece of cotton card fastened to a bit of wood, and drawn across the file in the direction of the teeth, the hook-form of card-teeth forming a ready means of cleaning the file of the dirt and filings. The files used by wood-workers may be cleaned in the same manner.

FILING A FLAT SURFACE.

THE proof of a good filer is his ability to file a flat surface perfectly true; and in this, simple as the operation may seem, there are but few adepts. It would seem at first thought that a file made perfectly straight and true ought to produce a corresponding true surface, but a file with a perfectly true surface is seldom met with, for by the operation of cutting the teeth and hardening and tempering all files are apt to spring and warp more or less. It is on this account that the common kinds of files are made with convex faces, and also wider in the middle than at the ends. Granted that files could be made perfectly true, as in the using of them there is no guiding principle, nothing except skill to direct the muscular action of limbs that move in arcs of circles, another great difficulty presents itself, yet by patient perseverance a pretty true surface may be obtained. The best instruction to be given is to lay the file lightly on the surface of the work, concentrate the mind on the object to be attained, and then with a slow and steady force move the file in a right line, as near as possible coinciding with that the file occupied before it was moved over the surface of the metal, avoiding a rocking motion. Care and practice are the only guiding requisites to produce a level surface with the file.

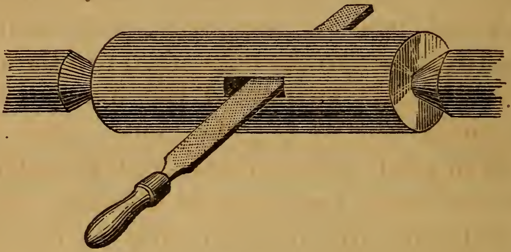

Fig. 2.

Many kinds of work may be partially rotated to compensate for the swaying of the file, by fixing the material to be filed between centers so as to turn easily, and the centers of the machinist's lathe presents a ready means for this purpose. If we have a spindle which has been nicely turned and finished in the lathe, and through this spindle we wish to make a mortise or key-way, we can commence by drilling several small holes within the prescribed limits of the mortise, and then cut out the intervening metal between the holes with a narrow cold-chisel, then support the spindle between the centers of the lathe, and the mortise can be easily and nicely filed to the desired form and limit.

If it be desired to make a key-way of some length, directly in a line parallel with the axis of the spindle or shaft, the lines to guide the diameter of the mortise may be made thus: place the spindle between the centers of a feed lathe in the same manner as when it was turned, and screw up the dead center so that the work will not rotate easily upon its axis; then place a sharp-pointed tool in the tool post of the lathe, and with the hand-wheel attached to the lathe-feed run the point of the tool along the surface of the spindle as far as the intended mortise is to be made; then turn the spindle or shaft between the centers until the tool-point will mark the opposite diameter of the mortise, and run a line parallel with the first line; by turning the spindle a half revolution, and repeating the lines on the side presented to the tool-point, the outline of the opposite side of the mortise is made.

There are many kinds of work in thin metal that it is necessary to nicely finish up; metal patterns for foundery use may be mentioned as an example, and, often being thin and delicate, will not admit of being inserted in the vise to be held for manipulation. These may be operated as follows:—Fit a

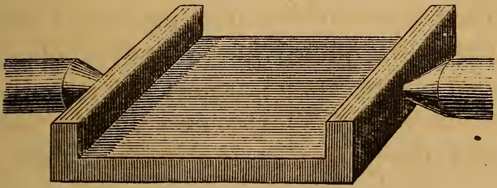

Fig. 3.

board or piece of hard wood in the lathe in such a way that the line of the centers will be in the same plane with the surface of the board. This can be done by nailing two cleats upon the ends of the board, the centers finding a bearing in the cleats; then fasten the work to this board by means of small nails, and as the file is applied it will oscillate sufficient to present its surface properly to the surface of the file, and by having the centers upon which the board hangs on a line with the surface of the work upon which the file is engaged the work will have no tendency to rotate by the applied force of the file.

The methods by which the work can be held to this tool for manipulation are various. Clamps similar to those shown in Fig. 4 may be applied, or holes may be made in various positions, and the work can be held by the heads of screws which fit into these holes, or if the work be very thin, as sheet-brass, iron, or steel, small tacks may be driven into the wood at suitable distances around the surface of the work, but in contact so as to retain it in place.

The usual method of holding forms of sheet-metal, such as patterns for various articles or the articles themselves, is to place a block of wood or a piece of plank between the jaws of the vise, and upon the smooth upper surface of this block insert a number of pieces of wire, or even small nails, which shall so hold or retain the work that it may be operated upon by the files or polishing implements, as is required. Where the articles are small, and there is a quantity of them, it will pay, perhaps, to fit up a wooden block; yet, even when so fitted, it is by no means a perfect method of holding work. Where the articles to be wrought upon are large and of various shapes and characters, and especially if they are very thin, it takes some time to arrange and fasten them upon the wooden blocks.

The cut represents a tool designed to hold work of this character. It is made of cast-iron, and when viewed from one of its ends is of a T-form, and its length or size is proportionate to its intended use. The lower or vertical portion is intended to be held between the jaws of the vise, and the flat surface of the upper part is nicely and evenly planed to receive the work when placed upon it. Two stout straps, made of iron or steel, are fitted to slide upon the projecting sides, and can be confined in any place upon the flat surface of the tool by means of set screws, which are inserted at the under side of the implement at each end of the sliding strap. If it be so desired, these straps upon the side where they come in contact

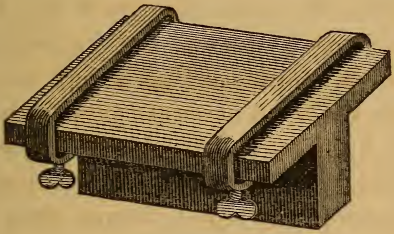

Fig. 4.

with the plate, can have teeth cut upon them similar to the teeth of a file, and they will then hold the work very secure; but for finished work smooth straps must be used, as these teeth would indent the surface and mar the finish of the work. It might be well, perhaps, to have two sets of these straps. If the surface of the tool be left a little rough, as the tool of the planer would leave it, and as the line of the cut runs longitudinally, it will assist materially to hold the work in place.

When the work to be operated upon is confined at each end, the middle portion of it is left free for manipulation; and when that portion is finished, one of the straps can be moved to clasp this portion, and the unfinished part can then be wrought upon; and when that is finished, the strap can be moved to its former place, and the other strap moved and the remaining portion of the work finished in like manner.

A modification of this tool can be adjusted to the drill press where a series or a great number of holes are to be made in irregular forms of sheet-metal, and it is necessary that the operator use both hands, as would be the case if it were a plate of steel, the workman feeding the drill with one hand and supplying oil with the other. It it be desired to turn or otherwise work sheet-metal, this tool can be easily held or confined by means of an eccentric or independent jawed chuck, having either two or four jaws, so that it will revolve, and its position or the position of the work can be so changed that any part can be reached with the turning tool, or whatever tool may be brought to bear upon it, as in case of an ornamental pattern with bosses, swells, or other forms to be turned or finished. If the work be a pattern which is to be chased or engraved, this tool presents a ready means of holding it for that purpose.

It is also a very convenient as well as useful tool to hold their plates or work made of their material that are to be polished or finished with a buff-stick, or by means of emery paper which may be wrapped around a file for that purpose. It is almost needless to add that when this tool is made of iron or other metal, the upper surface where the work is confined must be planed and finished quite true and even.

If the work be of such a nature as to demand it, or it be of such form that other than a plane surface is required, a piece of hard wood can be fastened to the upper surface of the tool by means of screws, and it can then be shaped to fit and receive the work. Pieces of metal of different forms can be also attached in the same manner. Sometimes soft metal, as type metal or lead, can be moulded to fit the work, and these castings can be attached to the tool by screws or by the clamps in the same way that work is held.

There is much need of a tool to be used by the filer and pattern-maker which will operate upon the principle of the lathe-centers in the operations we have just described. It might be made like a short lathe-bed of about two feet in length, with two heads similar to the sliding head of a lathe, each head to be fitted with steel centers similar to lathe-centers. The work then could be inserted in it in the same manner as we have described in the lathe. If it be desired to file the edge of flat surfaces at an angle, the work can be fastened to a metal plate or a piece of board and elevated to the desired angle, and will be in a ready position for the easy use of the file. In centering a piece of work preparatory to turning it in the lathe, it is the common practice to confine the work in the vise, mark the center as near as possible, judging by the eye, and then insert the work in the lathe, and by revolving it with the hand ascertain to which side the center mark must be moved. It necessarily happens that much time is lost by the workman going from the vise to the lathe and returning, and many times the lathe is wanted for other purposes while the workman is trying the centering of his work in it. But with the tool we have mentioned to stand beside his vise, he can center work at his leisure and get it nicely true and ready for the lathe without trying it in the lathe-centers until it is placed there to be operated upon by the lathe-tools.

VISE FIXTURES AND ATTACHMENTS.

THE jaws of vises are usually faced with steel, which is cut similarly to a file and then hardened and tempered ; consequently when material softer than the vise jaws is inserted and clamped in the vise, the marks of the file-like teeth are left upon the material. To obviate this it is customary with mechanics to fasten slips of leather to the jaws of the vise with some kind of adhesive substance, or form clamps of pieces of thin brass or lead, which are placed between the vise jaws, and then bent over the top of the jaw so as to remain in place when the jaws are separated for the insertion of the work. These clamps may be advantageously used for thin or delicate work, and can be removed when larger or rougher work is wanted to be inserted and held fast.

A most convenient tool to be used in the vise for filing angles is represented in Fig. 5, and ought to be made a necessity with every one who has occasion to work small articles, the edges of which are at more acute lines than a right angle. The most convenient position for filing is in nearly a horizontal line, and as the lines of the jaws of this tool, which clamp the work, are at an angle of about 45°, consequently the work will stand at that angle, and it requires but a little inclination of the file from the horizontal to obtain a very sharp chamfer. The shoulders of the tool, seen underneath the jaws, enable it to rest securely upon the vise jaws; the spring seen between the lower portion of the two parts that compose the tool pieces, forces its jaws open when the vise in which it is placed is opened. This tool is much used by gun-lock makers to file the bevel or chamfer upon the edge of gun-locks, and is well adapted to any similar work.

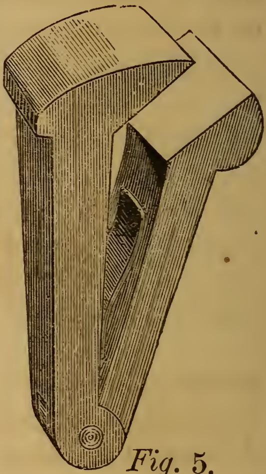

Fig. 5.

The mechanic is often called upon to file and work upon pieces of cylindrical metal, as pieces of rods, tubing, or wires of larger or smaller dimensions, and the vise presents no ready means of holding the same without bruising it. Let him have some false jaws cast of brass, or even of cast-

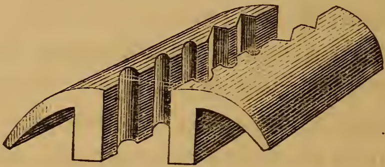

Fig. 6.

iron, similar to Fig. 6, in which he can easily file a series of triangular or half round grooves, in any direction, in each piece, as shown in the cut, so as to correspond with each other when placed between the vise jaws. For squaring the ends of rods or wire, or for holding the same for the purpose of cutting screws upon them, as the making of small bolts for an example, no better vise fixture can be found.

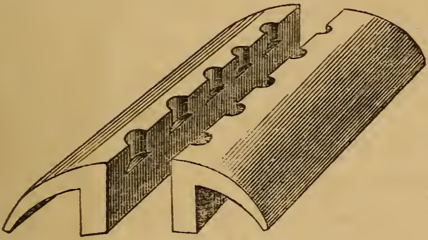

Fig. 7.

A tool for holding the common wood screw by the head is often needed by the mechanic and artisan; and a tool for that purpose, fully shown in Fig. 7, is very easily made from the same set of castings as those of Fig. 6, and by sinking indentations along the face of the fixture near its upper edge, similar in form to the reverse of a screw-head, and the filing small grooves to continue from the indentation to the edge of the jaw, for the purpose of more securely clamping the body of the screw. If it be desired to cut screw-blanks with threads of different degrees of fineness, this presents a ready and secure means to hold them for that purpose.

To hold work of a tapering or pyramidal form, vices have been made with one jaw movable upon a pivot, which will accommodate itself to the surface of the work; but it is not every mechanic that has a vise of this kind at his command. Some workmen do not like this kind of vise, as they claim that the movable jaw is not so firm for holding work as a vise with solid jaws. We have seen some workmen, when they had a piece of taper work to operate upon, insert pieces of spikes or select bits of iron from the scrap pile, and place them between the smaller diameter of the work and the vise jaw; but a most ready and sure attachment may be made of a piece of steel of a triangular form, as shown in Fig. 8, the apex of which may find a bearing upon one vise jaw, and the base being presented the same as the vise jaw, to embrace the work presented to it. A means by which this fixture may be supported in a line with the hight of the vise jaw may consist of a yoke clasping the neck of the vise, and having a projection through which a stem from the triangular piece of steel passes.

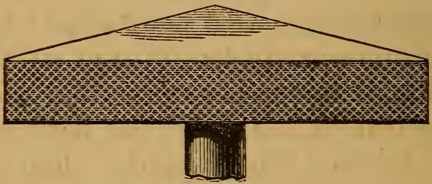

Fig. 8.

THE "DRIFT."

The "drift" is a tool that may be employed in lieu or in the absence of a punch and die, and equally as good work, if not better, can be accomplished as with those tools, and it also has the advantage of being used where the punch cannot be brought to bear, and will stand more severe and rough usage than the punch is capable of.

In construction the drift is made of a bar or rod of steel of appropriate length and with a transverse section of the precise form that the mortise or aperture is designed to be, but with the entering end of the tool much smaller than its body, and increasing until it arrives at its full proportions, and then slightly decreasing to the upper end so that it will pass freely through the opening the larger portion has made. The sides of the tool, commencing at its entering end, are cut with coarse teeth about ten or less to the inch, each tooth being made not at a right angle with its lengths, but sloping backward or made at an angle meeting a tooth upon the adjoining face. When teeth are cut upon all sides of this tool, it will resemble a coarse, many-threaded screw, with a thread commencing upon each of its sides. When the drift is made cylindrical in form, the cutting edges can be produced with an appropriate turning tool in the lathe, after the manner of cutting screws; but those of a square, triangular, hexagonal, or other polygonal forms must have the teeth or cutting edges cut with a planer or a milling machine; or if these tools are not accessible, the file must be employed in their stead.

Unless the mechanic wishes to make a succession of holes of the same size and form, the drift cannot be employed with economy, but when a dozen or more of similar-shaped apertures are wanted the advantage of the tool is apparent. The best of steel must be selected from which to make it, and great care must be exercised in the forging and making, as well as in the hardening and final tempering; and when carefully made and proved good by trial, the confidence with which it may be used without fear of its being destroyed will amply repay the cautious care used in its construction.

We remember to have been once employed in a shop where a quantity of small wrenches, made of sheet steel, were needed to use upon a hexagonal nut which clamped the needle of a sewing machine to the needle-bar. The practice, in making these wrenches, had been to drill a hole of about three-eighths of an inch in diameter, and then file it out to fit the nuts, which were about that diameter when measured across two parallel lines of their sides. One day when work was dull the job was given us to do, and instead of at once commencing to file at the wrenches, we astonished the fogy foreman by leisurely forging and filing up a blank-drift that would be of the exact size and shape of the hexagonal hole in the wrench, and then filed a succession of teeth upon each of its six sides. We tempered it and commenced our labor. The end of the drift which was to enter the hole bored in the wrench-blank was a little smaller than the hole, and was of a gradual taper as it was formed to a hexagonal shape, so that upon being driven into the hole it cut gradually until it had formed the hole of sufficient size, and then it decreased in diameter so that it passed easily through the hole thus formed. When we had finished the tool we began operations, and in less than an hour we had accomplished more and better work than the filer would have done in a day, and the holes formed with this drift were of an exactness and equality of angle that the filer could not possibly attain. This is one of the many examples in which drifts can be employed upon thin metal, as brass, iron, or steel. It matters but little what the shape of the drift may be so long as it is of a form that cutting teeth, similar to a coarse file, but not so fine or acute, may be made upon its several sides. We have found that ten teeth to the inch is a very good number, and it is better to cut them at an angle with the side of the drift of about the width of one tooth, so that the teeth in the finished drift will follow around its circumference like the threads of a screw ; a new tooth will consequently commence at the bottom of each side of the tool ; a square drift will resemble a four-threaded screw of that form, and a hexagonal shape will have six threads, or six successive lines of teeth.

Another example of the use of the drift is in the square mortise of the lower jaw of the slide wrench, through which the bar of the wrench passes. To use this casting (for it is made of malleable cast-iron) as it issues from the foundery would be detrimental to the wear of the wrench from the sand which adheres to the casting getting into the screw, as it would be abraded from where it adhered by constant wear. To file out this rectangular space would be a long and tedious operation, involving much wear and consequent cost of files ; to punch it with a press presents great difficulties ; but with a suitable shaped and properly made drift the whole thing is done quite expeditiously and cheaply, three or four blows of a hammer generally being all the force required to drive the tool, at one operation, through the two holes of the casting.

Tools called drifts are often made of the required form and used without cutting teeth upon their surface, but if this form of drift has any great amount of work to do, no workman will attempt to use it, without a cutting or serrated surface. As the hammer will somewhat batter up and spread the diameter of the drift-head, it is better to contract this diameter for a short distance from the upper end.

The key-seats in wheels and pulleys may be expeditiously made by means of a drift, as shown in

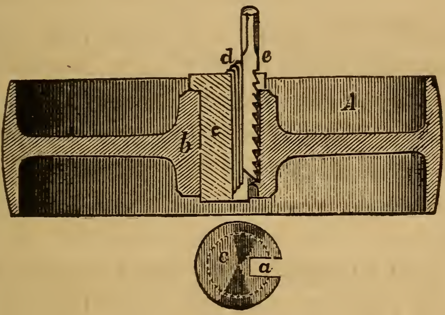

Fig. 9.

Fig. 9. A short cylinder of metal as at *c* must be turned to fit the hole in the hub *b* of the pulley, and a longitudinal groove *a* cut in this cylinder of the width of the key. The depth of this groove is of but little account, as the groove is merely to serve as a guide to the drift, to make a hole exactly its counterpart. Place this cylinder in the bore of the wheel and insert the drift *e* in the groove of the cylinder and drive it through, and, as teeth were only cut on the surface of the drift next to the wheel-hub, we see, as a result, that it has cut a shallow keyway or seat. To make the next cut and a deeper one, we insert a piece of thin steel or other metal as at *d* in the guide-recess of the cylinder and again drive the drift,

and it enlarges the key-seat of a depth corresponding to the thickness of the slip of steel we inserted in the groove of the cylinder. Proceed in this manner until the keyway is of a sufficient depth.

This practice is quite old, and the use of the slotting-machine and planer have superseded it; but as there are instances where it is required to form keyways, and the machines we have mentioned are not available, we think the process might be revived in some instances with profit and advantage.

The forms in which drifts can be made and used are of great variety, and they can be successfully employed with but little wear or injury, provided they are properly used and the angles which form the side are not made too acute. The cutting teeth should not be too slender, or they will break or nick off; nor too obtuse, or they will have a tendency to act in such manner as to strain the metal through which they pass. If a hexagonal hole is to be produced, as would be the case were a wrench to fix nuts of a hexagonal form to be made, the drift would necessarily be of this shape and size in its largest transverse section. To use a drift, a hole as large as can be made consistent with the character of the work, either by drilling or other means, is first made, and in this hole the entering end of the drift, which end ought to be about the size of the hole, is inserted, and the drift driven through, either with a hammer or by the action of any suitable mechanical appliance. As the tool passes through the metal, each tooth cuts off a clean, thin shaving, and the surface of the work is left more smooth and true than can be effected by any other simple means. The drift may be used to advantage in some metals and some situations to follow the punch to remove the strained portion of metal produced around the surface where the punch has passed. It may also be used to produce any inequality of form which could not be very well made in the punch; and with the exception of the part to be made to act, the tool can be left blank or smooth, and in operation it will follow in the track of the punch, cutting out the form as desired.

The limit of size of this class of tools has never been determined. But from the success of those even rudely-made and used with severity, it is evident that appliances of like character can be also successful when made of considerable size. The cutters of such tools might be made detachable and taken out and ground when their edges become dulled by use. The means employed to actuate these tools might be the lever or the screw for smaller sizes, and for the larger sizes hydraulic pressure is applicable. There is little doubt but that engine cylinders could, after a rough turning, have their interior surfaces finished with a drift suitably made and forced through with the means mentioned. Such a surface would have the advantage over that produced by the boring bar, inasmuch as it would be of equal and constant diameter throughout, and the lines produced by the tool would run in the same direction as those in which the piston is to travel.

COLD CHISELS.

To the mechanic who would have his tools of a neat proportion and attractive form we will say a word about cold chisels. Select about three sizes of octagon steel—say one-half inch, three-fourths, and one inch diameter. When you forge your chisels make them respectively six, seven, and eight inches in length, the half-inch steel furnishing a chisel six inches long. Then forge the width of the cutting-edge of the chisels respectively three-fourths, seven-eighths, and one inch in width; grind the cutting-edge to meet at about an angle of 60°, and when using the chisel upon a plane surface hold it elevated at about 45° with the line of the surface being cut, reference being had to cutting cast-iron.

It is not to be supposed that this angle of 60° is suitable for all kinds of chisels that are employed upon iron or other metals. Far from it. This angle is mentioned as the best adapted for strength and rough usage as may be employed for the purpose of trimming, casting and similar operations. For some kinds of work the chisel edge may be formed with half this bevel, or with an edge, the lines of which meet at 30°.

The material, the form of the cut to be made, and the purposes of the cut must be taken into consideration, and the angle of the cutting edge of the chisel proportioned accordingly. The judgment of the workman must be called into requisition, and he must shape his chisels as the exigencies of the case demand.

We have seen projections left upon the castings of machinery which were unsightly and would not be tolerated by a neat workman, because the workman had no cold chisel to use as a part of his stock of tools. Then, again, for the same reason, we have seen workmen leisurely file away a spur or protuberance, when two or three blows with a hammer and a cold chisel would have accomplished the object in almost as many seconds. Excepting a scarcity of steel, there is no excuse for want of a cold chisel to be found wanting at the vise of the workman, and with its employment there will oftentimes be a great saving of that somewhat costly tool, the file.

GAUGES, CALLIPERS, DIVIDERS, ETC.

It is in such tools as these—gauges, callipers, dividers, etc.—that most mechanics are deficient in being the possessors, and they are the very tools most needed, and tools which the mechanic should himself own. To purchase at a hardware store all of the small tools that are or ought to be the necessary adjuncts to the lathe and vise would require quite an outlay, and one which few workmen are willing to incur, and so they often make a shift, and a poor one at that, when they can, to get along without purchasing them. We advise every mechanic to make his own tools if he possibly can. Some he must of a necessity purchase, and among these are the spring dividers and callipers. We would recommend him to get two sizes of each, a pair of four-inch and a pair of six-inch. On small lathe or vise work the four-inch instruments can be handled with much greater ease than the larger sized ones, and the six-inch instruments will be called in requisition only for larger work; and on common shop work it is seldom that the workman needs either callipers or dividers above six inches in length.

The best form of callipers, and one which the mechanic can easily make, are represented in the engraving, Fig. 10, and are represented of actual size. They are made from sheet steel of about one-sixteenth of an inch in thickness. To make them, cut out a pattern in paper, which paste upon a piece of sheet-steel of a size large enough to make one leg or side of the instrument; then with a cold chisel rough this out to the edge of the paper, and also one of similar slope to form the other leg; drill a hole for the rivet, which ought to be about one quarter of an inch in diameter, and with a piece of iron or wire driven into this hole fasten both pieces or legs together, and then clamp them in the vise and file them to the form as indicated by the paper pattern. They can then be taken apart and polished, or otherwise finished. Form a rivet with a head of the slope of one side of the boss and make a washer similar to the opposite one, but with a countersunk hole that will snugly receive the rivet. Place the parts in the positions they are to occupy, and lay the rivet head upon a piece of lead or hard wood, and head down the rivet upon the washer. File off the surplus metal and finish similar to the rivet head. These callipers are made very readily and answer as good a purpose as the more costly tools They are both outside and inside callipers, and the ends exactly correspond in either inside or or outside measurements, no matter at what distance opened.

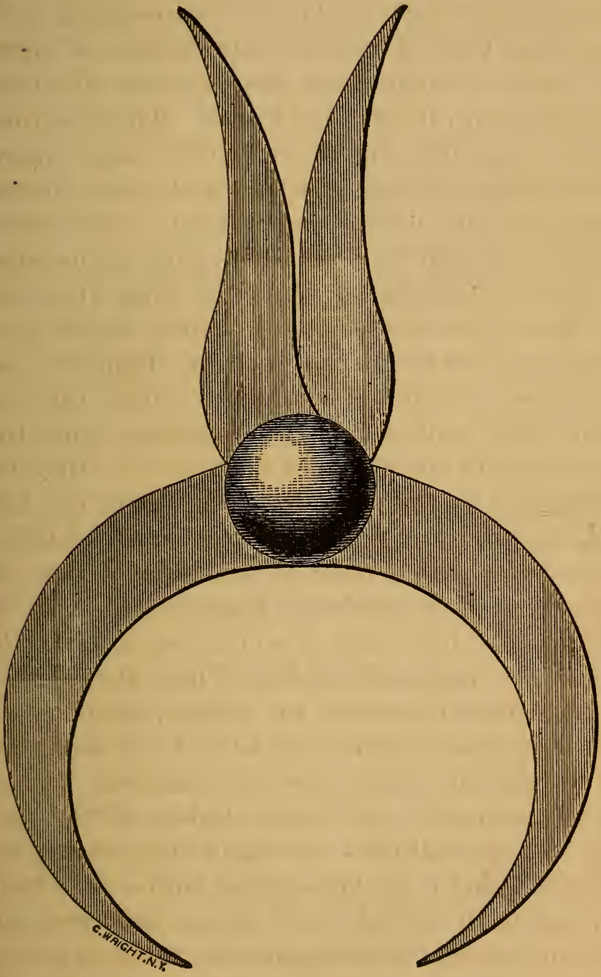

Fig. 10.

Of scales or steel rules we would recommend a four-inch scale, of which one side is marked with the inch divided into eighths, sixteenths, thirty-seconds, etc.; the other side having the inch divided into tenths and other decimal divisions. We would advise the workman to calculate all possible measurements of less distance than the inch in tenths. In connection with the four-inch scale or rule it is necessary to have a twelve-inch scale. In selecting this choose one with the divisions on two lines, like those of the four-inch scale above-mentioned, and with the other two lines divided into fractional parts of the inch, which are not included in the divisions of decimals or fourths. These odd divisions will be found very useful in measuring the threads of screws, or by trying the different divisions upon the screw-threads it will be readily seen which conform, by the lines on the scale being exactly coincident with the sharp edges of the thread.

Many workmen use the tools we have mentioned for all of their measuring, callipering, etc., but where a constant measure is to be kept of a certain size it is best to make solid gauges, and for small work iron or steel about one-eighth of an inch in thickness is advisable. Select a piece of metal of this thickness and one inch in width and cut in pieces just four inches in length. Keep several of these in the tool chest or drawer ready to be used when wanted. In one of these pieces drill a series of holes at proportionate intervals, of diameters increasing by tenths; make the first hole one-tenth, the second two-tenths, the third three-tenths, and thus continue to increase by tenths until you have several holes to serve as standards for future measurements. If you have drill or rimmer shanks, make the chuck-center in which they are to be inserted of the size of one of these holes in your gauge, and then you can use the hole in the gauge as a sure guide to turn or forge the shank of the requisite side. From one of these four-inch pieces you can make a V-gauge by which to turn up lathe centers to the necessary angle of acuteness and also make a rose-bit center of the same shape for centering shafting and other work, and the centers thus made will exactly correspond to the lathe center. Another V might be cut in the gauge as a guide for grinding the cutting sides of drills to the angle 90°, as that is the best angle by which to form the points of drills. For any fixed or definite size to which several pieces of work are to be

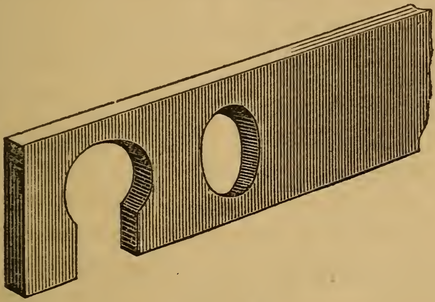

Fig. 11.

fitted these blank gauges are brought into use. It takes but a few minutes to form the gauge aperture, and as it will remain constant to the size, the workman can progress without fear of deviation being made in his work, if he only be careful that his gauge be rightfully applied. In making a gauge aperture to fit a small cylinder or rod, as a drill shank, make a larger hole in the blank than is wanted, and fill a space through from the hole to one side of the guage of the exact width to correspond to the diameter of the work. This form is

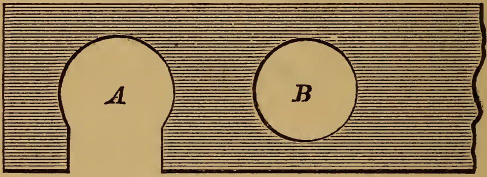

Fig. 12.

shown in the annexed diagram, which diagram is represented as the form of a gauge of five-tenths or half-inch. The space A, and the opening B, are both of the same diameter and both used for the same measurement.

If the workman makes a triangle of a piece of sheet steel, the right angles of which triangle will be about four inches in length, he will find it of use in many places where he cannot employ the fitting square; it can also be used for every purpose as the fitting square, and can he made by the mechanic in his leisure moments. In the hypothenuse side of the triangle an angular opening may be made, which will correspond to two of the adjacent sides of an hexagonal or six-sided nut or bolt-head. If it be required to file up six-sided work to a degree of accuracy this gauge will be found of much use.

A few tools or gauges, made in the manner we have described, will cost but a little more than the time to make them, and with ordinary usage will last for several years. If they are made of sheet steel and are subject to much wear at certain points, these parts can be easily tempered so as to resist the wear. In selecting steel or iron for gauges it should be about one-eighth of an inch in thickness, then there will be no danger of its springing when made into a gauge and applied to the object to be measured.

STANDARD GAUGES FOR SCREWS.

When we speak of a certain number upon the wire or sheet-metal gauge, any mechanic readily knows the size or thickness of the material mentioned. But when we speak of the number of threads or the size of a bolt, no one can tell exactly from the number of threads given what the size of the bolt is, or from the size given of the bolt what the number of threads is, or should be, upon it. In consequence of this, great inconvenience is found to arise from the variety of threads adopted by different manufacturers, and the provision for repairs in the different shops is rendered quite expensive, or if this provision be not made, the means for matching screws are very imperfect. It is a well-known fact that unless the threads of the nut and screw exactly correspond, and coalesce in length and depth, the mutual action is deranged, friction is increased, and the power and strength of the screw are both sacrificed.

In gas-pipes and gas-fixtures we have a very good standard, and a pipe ordered from a shop in one part of the country will be found to fit a thimble or a nut that is made in some other place. But common bolts are an exception. They seem to have been originally made and fitted up with all sorts of odds and ends of threads that have been cast off from other work. A faint effort has been made in some directions to overcome the evil by a uniformity of system, and reduce all screws to a standard, the thread being constant to a given dimeter; but thus far this effort has amounted to but little. The same odd conglomeration of screw-threads still exists, and seems almost to defy every attempt to reduce them to any kind of system.

What we want is a standard of gauges graduated to a fixed scale, as constant measures of size; and then corresponding parts, instead of being got up one to another, might be prepared separately. The indefinite multiplication of sizes would thus be prevented, and the economy of the workshop simplified beyond calculation. Let all bolts increase in size by tenths of the inch, and let all threads when finished be exactly of decimal measurements. Then have a standard gauge of thread to each size of bolt. For three-tenths let it be eighteen threads to the inch; four-tenths, sixteen; five-tenths, or half inch, fourteen; six and seven tenths, twelve; eight and nine tenths, ten; one inch, eight; inch and a half, six; and a two-inch bolt, four to the inch.

Let some manufacturers introduce a system of gauges to fit these threads, measured by tenths, and made more perfect than the old gauges in use. Let there be a measurement for the threads per inch, a gauge for the full size of the threads, and one for the bolt, if the threads were wholly cut away. There would then be a double use for this gauge—it would not only measure the bolt to fit a hole in a certain piece of work, but give the size of hole that it is wanted to cut a thread in to fit the bolt.

Let gauges like this be introduced into the shop as a part of its necessary tools, and they will soon reduce all bolts to their standard, and by so doing save a multitude of vexations to the mechanic and the manufacturer.

In all of the jobbing machine-shops we still find the old-fashioned taper tap in constant use for several series of bolts; but introduce the decimal gauge as a standard, and the old taper taps will soon be thrown aside, and manufacturers can supply the market with straight and plug taps, and in decimal sizes that will be *warranted to fit.* The same manufacturers that supply these taps can also make a business of manufacturing counter-bores and fluted-reamers, all made to correspond with and fit this decimal standard gauge. We hope soon to see some move made in this direction, and hope that a better time will soon dawn upon the troubled mechanic, who now labors under many difficulties and gropes in the dark and confusion of cutting and fitting bolts in the machine, jobbing, and repairing shops.

THE ANGLE OF 60°.

In forming the cutting angle of tools, as used by the iron-worker, no very definite instructions are given. The apprentice copies as near as he can from the master or more experienced workman, and they work in the manner in which they were taught. Every mechanic has at times observed that there was a certain angle which, when given to the cutting lines of tools, was more effective and resisted the action of the material in which the tools operatod, better than others; but with the exception of an effort to remember these lines by the eye, he has no gauge or guide to assist him in the production of the same angle again.

It is generally acknowledged that the cutting angle of a lathe-turning tool operates best, is the most effective, and has the greatest strength, when formed with an angle of about 60°; and this same angle, which in tools of this kind may be called the *angle of strength*, can be formed to advantage in all tools which are used to operate in iron or steel.

The angle of 60° is easily formed and as easily remembered. To obtain the proper proportions, insert a circle, and in this circle draw an equilateral triangle, the points of which intersect the diameter of the circle, and this angle has 60°, and has been found by experience to be the strongest and most durable form that can be given to an iron-cutting tool. If the reverse of this angle, or an indented V of the same form, be made in a piece of metal, it will form a gauge or guide by which to form the cutting edges of nearly all the tools of the iron-worker.

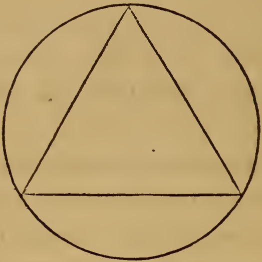

Fig. 13.

We have mentioned the lathe-turning tool as an instance of the efficacy of this angle. The chipping or cold chisel is another example, and there is no tool the edge of which is subjected to a greater amount of rough usage and strain, and more liable to give way, than this simple tool ; but if its cutting angle be formed to lines which meet at an angle of 60°, it will be found to stand more blows and wear longer than any other angle. For delicate work a more acute angle may be used, but for ordinary purposes this angle will be found the most serviceable.

The same angle can be used in the cutting angle of the flat and twist drill, but there is a greater efficiency in the twist drill over the flat one, and for the reason that the angle is more acutely presented to the work than in the flat drill. The counterbore or pin drill, and the chasers employed to form screw-threads, are examples in which this angle could be advantageously used, giving the tools greater strength and durability. In some of these tools the angle is differently presented to the work than in others, yet the same number of degrees may form the lines of the cutting edges. We have said that this angle of 60° is the angle of strength, and we mention the instances in which it may be advantageously employed to obtain a more serviceable tool, yet say nothing of the manner in which the apex of the angle may be presented to penetrate or work in the metal.

The shears used by the worker in sheet-iron are best formed with the edges of each of the severing blades at the angle we have described. Let them be once so formed, and experience will decide in its favor.

The screw-tap ought to be grooved to conform to this angle, and when it is made with three grooves, which is undoubtedly the best mode of forming a tap, the proper angle, or rather the form of the triangle, supposing it to be seen in section, can easily be given to it, supposing the circular part, as it recedes from the cutting edge, be made in a straight line. If more than three grooves are made, each cutting edge must be considered as *one point* of an equilateral triangle, and if there be six grooves, it will represent two of these triangles laid upon one another, and the angle of 60° must apply to each individual point. The same rule and the same angles must apply to the threads of bolts and nuts ; the shape of a bolt-thread must be measured with this angle and conform to it. The tool that is used in the lathe for cutting these threads must be also formed to 60°, and accurately fit the V-gauge when it is applied ; and in addition to the cutting lines of the tool being thus formed, a greater strength is gained if the cutting angle and the front line of the tool be formed with the same angle of 60°.

The teeth of mills, reamers, and circular saws for cutting metals operate as a series of revolving chisels, removing whatever metal they come in contact with, and to get the greatest strength and maximum of wear their teeth must be formed with the angles as we have explained. When these tools thus made, are used in the heaviest work, they will seldom break or give away with any kind of fair usage ; but if they be made with a more acute angle will break or crumble, and if with a less angle will not operate as easily nor as effectively.

The lathe centers are best made when shaped at the angle of 60°, and, in fact, this angle has been recognized as a standard for their formation in many shops, while in others we see no attention paid to it, and the centers are made by "guess;" but it has been ascertained that the angle of 60° stands the best under all kinds of usage, and the same gauge by which they were shaped can be used to form the rose-head or countersink which is used to form the center in shafting and work to be turned, and it will then accurately fit the center of the lathe.

This angle of 60°, as an example of strength and service, can enter into the formation of nearly all of the cutting tools used by the machinist or iron-worker, and a simple gauge, made of sheet steel, will be found a sufficient guide to enable the mechanic to obtain it without any difficulty.

LATHE TURNING TOOLS.

PROBABLY no tool used by the mechanic is made with a greater variety of forms and shapes and more variously used than the lathe turning tool, and for the simple operation which it has to perform there is no tool that requires greater skill to make and greater care to keep in order. As we see the turning tools on the lathe of the machinist, we notice that they are made from bars of steel of sufficient width and hight to nearly fill the mortise in the tool-post in which they are placed to operate upon the metal to be reduced by their action. Has it never occurred to the machinist that of these tools only a very small portion is used to cut away the opposing material, and if he would economize time in grinding these tools when they were dulled by labor he must exercise some care and foresight in their construction? As it is customary in the majority of machine-shops for the mechanics to forge their own tools, we will venture to give a few hints respecting the construction of such tools. We have seen many workmen forge the projecting portion of the tool, the angles of which form the cutting edges, of a lozenge or diamond shape, because there were no fixtures by the aid of which to form it differently, the hammer and anvil being alone employed, and as a consequence it required much time to reduce the surplus metal whenever the tool was ground. They have remarked that, instead of the lozenge form, a triangular point would give the same amount of strength and the same length of angle of cutting edge, and less labor would be required to keep the tool in order by grinding when such operations are necessary. But with the hand-hammer and anvil alone no better form than the lozenge-shape can be produced. If a little time and labor were spent in making a shaper to be inserted in the angular recess of the anvil, and in the face of this shaper a V or recess be formed, extending across its surface, the needed triangular shape of the tool is readily made by first rudely forging the

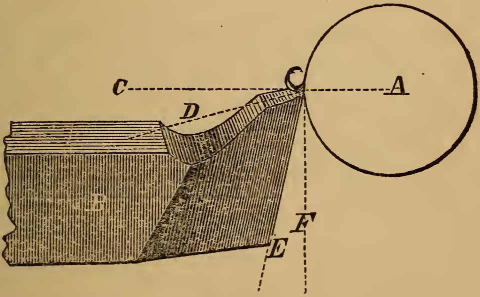

Fig. 14.

point upon the anvil and then placing it within the triangular recess and swaging it to the form with the hammer, the hammer blows forming the base of the triangle and the two sides of the recess, a right or left hand cutting edge as may be desired.

In Fig. 14 we present a sketch of what a cutting tool should be, and the angles forming its several lines of surface. A is a cylinder inserted between the centers of the lathe, upon which the tool, B, is operating. A, C is a horizontal line passing from the center of the work to the cutting point of the tool; D is the line of the cutting edge or angle; E a line passing from the cutting point along the front plane of the tool; and F is a line at right angles to the horizontal line, C. These angles may be better known by the following terms:—The angle formed by the intersection of D, E is the "angle of the tool;" the one formed by E, F the "angle of relief," as by its acuteness the friction of the face of the angle upon the work is increased or diminished; the angle formed by C, D is the "angle of escape," as it allows the material which is cut away to readily escape for further operation. The angle of relief should always be quite small, for if made too large the point of the tool will not have the support necessary and will be apt to break, and often in such a manner that a new tool must necessarily be made. If a tool has a tendency to *dig into* the work, a less angle of relief will correct its injurious propensity.

It must be borne in mind that the turning tool is but a *wedge*, whose point must enter the surface of the metal and *cleave* or *lift off* a certain portion, according as it is presented to the opposing surface. If the edge of the tool be too thin, or is exposed to a greater strain than its strength will bear, it will consequently give away ; but if made too obtuse, it does not cut, but roughly tears away the opposing metal, and operates in a very unsatisfactory manner. The angle of the tool must be that in which the minimum of friction and the maximum of durability is produced. For iron this angle is about 60°.

It has probably been observed by the machinist, as we have before remarked, that much labor is required to form his turning tools and keep them in repair, and the portion brought into service in cutting is quite small. If, then, smaller bars of metal could be made rigid enough, so arranged as to be fixed in the correct position, and thus re-

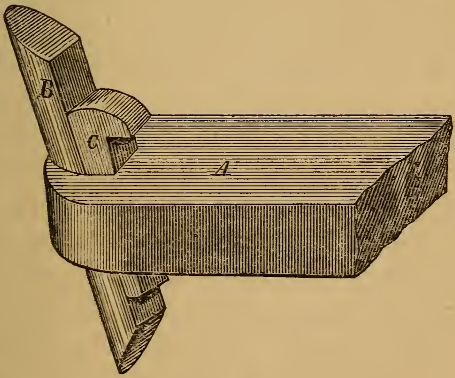

Fig. 15.

tained for use and at the same time be made removable for repairs and adjustable to compensate for the wear and grinding of the tool, an important result would be gained. Several attempts have been made to effect this, but no contrivance has yet come into general use. In Fig. 15 we give the form of a tool which we believe to be all that can be desired in this form. A is a bar of steel, made to fit the recess of the tool-post with a triangular or other shaped recess formed at the front extremity; in this recess is placed a short piece of steel, B, so made and fitted as to accomplish the same effect as the cutting point of the commonly fashioned lathe tool. Such points may be made of pieces of steel of a few inches in length and may be tempered their entire length and made reversible, so that either end can be used when needed. When one of these pieces is inserted in the stock, A, a gib, C, is driven in behind the piece and securely holds it in place.

In Fig. 16, is given another form of turning tool and stock. It consists of a bar of iron or steel gibs to the tool post and drilled longitunally to receive the stem of the clamp which holds the tempered cutting rod. A shoulder is made upon this clamp which is received in a corresponding recess in the bar. This serves to keep the clamp and tool steady. A nut screwed upon the end of the stem serves to tighten up the clamp to the steel cutting point, and consequently to the bearing surface of the bar or stock. Now, any apprentice, who knows enough to take a twist-drill and bore a piece of iron therewith, can make this turning tool. It will receive several sizes and shapes of steel rods if necessary, and hold them very secure.

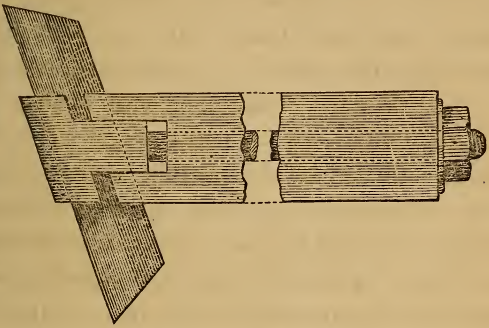

Fig. 16.

It has the additional advantage that the point can be removed for grinding or other purposes without removing the stock from the tool post of the lathe. Also, no blow severe enough to injure tool or stock need be applied to loosen the point to permit of its removal.

The introduction of lathe tools of the character above described indicates mechanical progress. The machinist's time is too valuable to be employed in forging a great deal of metal to obtain a small turning point, and with his lathe standing idle while he is thus engaged. In construction, the tool stocks and holders as presented explain themselves. The turning points are made of short rods or bars of steel and tempered their entire length. They can be reversed when one end is dull, and to facilitate labor several of these rods may be kept at hand ready for use. In the tool shown in Fig. 16, the turning point is held by being clamped between the movable piece and the stock, and is there secured by turning up the nut at the outer end of the stock. As before remarked a hammer is not required to loosen this point for removal, and the parts of the tool are very strong and simple. It can also be used as a clamp for holding wire or rods for filing, and may be used in the capacity of a hand vise for holding work for manipulation. We have seen lathes with which a slide-rest is used, provided with no mechanism or means to elevate the point of the tool as it was worn or ground away. The mechanic then inserts pieces of nails or bits of scrap-iron under the tool to elevate the point to the necessary hight, but with a tool like the ones represented this would be entirely obviated. And another advantage is evident, the forging and tempering of lathe tools like these are not required so often as with the commonly formed tool made upon the bar of steel, and the amount and weight of steel thus employed is materially reduced, a few pieces of small-sized steel rod, which require little or no forging, taking their place, and when they require grinding can be quickly removed and ground with little labor. This form of tool is equally applicable to the planer, the slotter, and shaping machine.

CARE OF THE LATHE AND ITS ADJUNCTS.

THE lathe may be considered to be the chief of all tools, as it is the principal one in the workshop economy. The care taken of it ought, therefore, to be in a corresponding ratio to its worth. Without the lathe modern mechanics would be nothing; the circular parts which so much enter into the conformation of all machines would be an impossible production. Let it be respected, then, for its great utility. We have often remarked, as we have entered a machine-shop, that the care and attention which appeared to have been bestowed on the lathe was the index to the general management of the shop, and a sure criterion of the manner in which the business of that establishment was conducted. If the lathes were neat and orderly, we were sure the proprietors were prompt and regular, and had an eye to business in all its details; but if, on the other hand, the lathes were disorderly, soiled, and rusty, we invariably gave that place a wide berth, and looked carefully how we dealt with the attaches of the concern. A man's habits will certainly be shadowed on the inanimate material with which he comes in contact, and that in its turn will disclose the characteristics of the interior life of the operative.

The lathe, as we remarked, is the principal tool of the machine-shop ; let the mechanic regard its care and use with a jealous eye. See that it is kept clean and free from dirt and stains of dried oil. It is necessary at intervals to oil the bearings, but do not allow the surplus oil to run down the sides of the head-block ; but if it should do so, immediately remove it with a handful of cotton waste. Some proprietors are too niggardly to provide waste ; but if this be the case, the mechanic, if he will, may find a piece of rag large enough to wipe his lathe with. We say to mechanics, do it at your own expense, rather than have the reputation of not keeping your lathe clean.

A hammer never ought to be the adjunct to a lathe, for with its use the lathe-shears will get bruised and battered ; always use a wooden mallet, or if one cannot be easily obtained, and the hammer must be used, place a block of wood between the place to be acted upon, and strike upon the wood instead of the work. A shallow tray or piece of plain board ought to be placed upon the rear end of the lathe-bed, and all lathe tools, hammers, chucks, etc., ought, when not in use, to be laid upon this board, and not upon the lathe-bed. More injury is caused to the appearance of a lathe by the careless habit of throwing the turning tools at random upon the unused portions of the bed, than by any other means.

Another abused adjunct to the lathe is the scroll chuck; and more real damage is done to it with the application of this tool than with any other. To put it upon the lathe-spindle we have seen workmen start the lathe at full speed, and hold the chuck to the screw of the spindle, retaining it in that manner until the shoulder at the terminus of the thread met the face of the chuck with a sudden blow, that arrested the force of the lathe and released the chuck from the hands of the workmen. When chucks are made to run untrue by such gross carelessness, we have seen workmen take a block of wood and a hammer, and with repeated blows endeavor to put them into their proper circle of rotation. After a chuck has been placed upon a lathe-spindle in the manner we have described, it will require some force to remove it, and the chuck-jaws present a ready means of applying force, and the hammer the instrument of force to start it from its place; we have seen an iron bar inserted between the jaws of the chuck and a powerful leverage thus obtained with repeated blows as the means of removal; the back-gear of the lathe being thrown into the spindle-gear and thus locked to prevent the rotation of the spindle, which would otherwise ensue. We have seen other workmen hold a piece of iron against the lathe-shear with one hand and with the other forcibly rotate the chuck against the iron. Chucks can be removed in this way, but we once saw a valuable chuck spoiled by the jaw breaking out from the plate as it met with this resistance to its rotation. We say place the chuck carefully to its place upon the spindle, and it will require but a small force to remove it when your work is completed.

Many chucks have their jaws operated by a ring, which is turned by means of a short piece of iron or steel rod. The holes where this rod is inserted are often very much battered and bruised unnecessarily. A good chuck can soon be much injured in this way. Have the rod of good steel, turned to fit the hole in the movable ring, and when you have occasion to insert the rod to move the jaws, insert it as far as the depth of the hole will allow and turn it as is necessary, but avoid all blows, jerks, and sudden wrenchings, which not only injure the chuck but also affect the lathe-spindle and its bearings.

APPLICATION OF LATHE APPLIANCES.

APPEARANCES would seem to indicate, in many machine-shops, that the engine lathe is all that is needed in the form of machine tools ; and with the lathe alone, if we except the file, the mechanic is expected to produce the various forms of work required ; which can be done, it is true, but at a cost of time and at a great disadvantage.

The lathe centers are always furnished with the new lathe when it is purchased, but they are only fitted to the spindles ; the points must be shaped and tempered. Instead of having a gauge to turn up these points, each mechanic suits his own fancy as to their shape, and as a result we seldom see two lathes with the same shaped centers. If rose-heads or half-round pointed reamers are to be used for countersinks of the work to be turned, we seldom find them to correspond with the center points, and often a slovenly workman will use the point of a flat drill instead of the appropriate countersink ; as a reason, perhaps, he is too indolent to make a proper tool for this work, or perhaps the niggardliness of the proprietor will not allow of time being spent in making such tools.

A gauge of the proper angle for the centers ought to be made, and then countersinks and centers, both made to *exactly* correspond to this gauge; and when the centers are thus made, carefully temper the *dead* center and leave the *live* center soft or untempered; the reason is obvious, if at any time the live center be found to run untrue, it can be corrected with a hand tool, which cannot be done if it were tempered. It is seldom that we see more than one pair or set of centers fitted to a lathe. There ought to be at least three sets; the one we have just mentioned, adapted for ordinary work, a set to correspond, but with indentations, instead of points, called female centers, of a depth of about one-fourth of an inch, to receive articles which are pointed instead of being squared and centered, and a larger set of centers of two inches or upwards in diameter, with the pointed ends made like cones, to be inserted into tubes or hollow shafts, if it be needed to turn or work such tubes.

The next appliance which should be fitted to the lathe is the drill chuck, and this should be made to *screw upon* the spindle, not made with a shank to be inserted into the hole intended for the center.

Two scroll chucks, a large one and a small one, ought to be the accompaniment of each lathe; the large one to serve for chucking pulleys and large articles, and the small one to hold smaller articles, short pieces of rods, wire, etc., which would be awkwardly held in the large chuck. An appropriate size for this small chuck is six inches in diameter, and the larger one nine to twelve inches in diameter, in accordance with the swing or size of the lathe. For ordinary work, a nine-inch chuck is sufficient. With the exception of the six-inch chuck, the mechanic must select those best suited for his work. Several kinds of styles may be obtained in the market, both eccentric and concentric, made with two, three, or four jaws. These chucks can be purchased at much less cost than the mechanic can make them himself, unless he be an amateur and wishes to make his own tools.

Accompanying the lathe as it is received from the manufacturer there is generally one face-plate fitted to the spindle. We would advocate the making of at least three different sized plates of this kind, to accommodate the different sizes of work to be manipulated, and also to accommodate the different lengths of the dogs or drivers that are generally employed in such work. A small driver makes an ill fit in a large plate, and a large driver certainly cannot fit a small plate; but let each size of driver have its own appropriate size of face-plate, then the drivers may be made in their proper proportions, according to their apertures and the work to be inserted in such apertures.

After the lathe centers are finished and the drill and other chucks are fitted, the next thing to be done is to remove the spindle from the tail-stock and make a screw upon its end precisely similar to the one upon the live spindle. This is very seldom or never done in shops, but when once made and used will be ever after deemed essential. The face-plates, the drill, and other chucks can then be placed upon this spindle and many operations performed which cannot be otherwise well done; portions of work can then be rotated in the chuck placed upon the live spindle, and the drill-chuck may be placed upon the dead spindle, and holding the drill or tool required to operate upon the work in a much better manner than to place the end of the tool against the dead center, and hold it from turning by placing a dog or driver upon it. The scroll or eccentric chucks may be placed upon the dead spindle, and drills or tools inserted in the chuck upon the live spindle. We have seen mechanics attempt to drill or bore small castings by holding them in their hands against the dead spindle, and the result of such practice is an unsatisfactory hole, and the operation is often attended with bruised or lacerated fingers, the result of the work "getting away" from their grasp. We hope this hint of a screw upon the tail-stock spindle will be of universal adoption, for its use will be evident from the example just mentioned. The chuck required to hold the work can be placed in position in a minute or two, and the work held with no risk or inconvenience.

Every manufacturer who purchases a lathe ought to be convinced that as much as the cost of the lathe ought to be invested in the appliances which are to be fitted to it, and then the workman can then feel that he has some conveniences to work with, and can accomplish his work in an easy and satisfactory manner.

These appliances when once obtained, or made and fitted, will last as long as the lathe, and the celerity by means of which the operations can be accomplished will repay the capital expended, for it is convincing to every one at this age that "time is money," and the one must be cared for and economized in the same manner as the other.

LATHE CHUCKS.

THERE are hundreds of small operations which, in many machine-shops, are done at the vise and with a file that can be done with the lathe, if a little ingenuity and a few hours of time were employed in making the proper tools. Some mechanics have the ingenuity, but will not apply it, perhaps from the mistaken idea that the proprietor or some one else will be benefited, and they will receive no emolument for the use of the emanation of their brains. It is the general idea of mechanics that their employer is entitled only to their *manual labor*, and the *mental* is required only of the foreman or whoever directs their operations ; and if a little study be wanted upon some unfinished portion of their work, they will coolly wait until the "boss" has again marked out a line of future progress. This class of workmen are but little better than machines ; they use their bone and muscle only, and work in a dull and automatic manner. It is very true that but few employers will permit their workmen to make experiments, as they often find that it is to *their cost* alone, as no profit accrues from these attempts; but as an excuse for allowing the operative to carry out some plan, we must say that there are many operations which, by the aid of a few simple fixtures, that the workman could easily make if he had only an idea of them, would greatly facilitate his labors.

We will suppose the mechanic has a round, an oval, a square, or any irregular-shaped plate of metal through which it is necessary to make a circular aperture, or form a screw-thread within the hole when made; we will suppose that the plate cannot be held either in the eccentric or concentric or independent jawed chuck, or if it could be held in these chucks, the lathe he is to work upon is not provided with them. Let the mechanic then fasten, by means of common wood screws inserted through the back side of the face-plate, a piece of plank or thick board of some hard wood to the face-plate, and turn it off to a size somewhat larger than the face-plate. Then fit two strips of iron across the board, as shown in the cut, and fasten the straps at each end with bolts to the face of the wood. The heads of these bolts ought to be made square, and sunk into the wood next to the face-plate. The square head will prevent their turning round when the nuts are screwed up, and by the heads being inserted next to the face-plate will prevent the bolts from

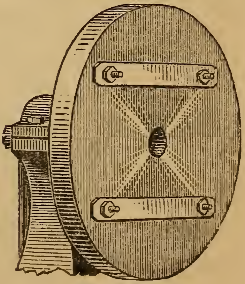
Fig. 17.

getting lost, if it be desired to keep the board upon the plate. A chuck can be made upon this plan which will be very often found useful, by screwing the bolts directly into the face-plate without the intervening piece of board; but it is best to put on the board, as by so doing the point of the turning tool will be in no danger of passing beyond the inserted work, and thus injure the face-plate or spindle. It would be well to turn a recess in the back of the board in which the face-plate will accurately fit, and this will be a guide to always keep it truly in its place. The wood of a chuck of this kind can be easily renewed at any time when it is much worn or bruised, and when it is necessary to remove it from the plate, by keeping the bolts and straps in their proper places they will be in no danger of their getting displaced or lost.

This appartus can in many kinds of work take the place of the scroll and eccentric chuck, and will at the same time securely hold work that cannot be contained in either; it is cheap, easily made and fitted, and would be an economical fixture to the jobbing lathe.

The handles of wrenches, such as are used for taps in screw-nutting, are often turned very neatly, but the flat or square parts are either filed up or left unfinished; if there be no planer in the shop there is no ready means to finish this flat surface; but if the mechanic has one of the chucks or fixtures which we have just described, the wrench can be turned off true and nice on the flat surfaces. The handles of the wrench must rest against the bolts as it is confined by the straps, and it will, if properly secured, be impossible for it to get loose or out of place.

We have observed in many shops that the want of chucks and lathe attachments is much felt, yet the proprietor seemed to think that when a lathe was introduced to his premises nothing more was needed, and that chucks and face-plates are a sort of costly superfluity which *could* be dispensed with. But as we have before remarked, on the introduction of a lathe into any establishment there ought to be immediately fitted to it several drill chucks, a concentric and an eccentric chuck, and a screw ought to be made on the end of the dead spindle, so that the various chucks and tools can be placed on either the live or dead spindle. The advantage of this will be apparent, the drill chuck can be screwed on the dead spindle, and the work can be held in chuck or fixture which is placed upon the live, or *vice versa*. Round iron or circular plates can be held in this manner, and the hole made will be "true" to the face of the work.

The number of chucks and fixtures that are adapted to especial ends is unlimited, but it is the lathe fixtures which are called into requisition for general purposes that we desire to mention—tools which are adapted for the jobbing and repair shop, where it is seldom that an especial tool is called in requisition the second time, or, even if it be so, it must be altered so as to be fitted for the operation, and is then unfit for a piece of work similar to the one for which it was first made.

The form of chuck which we illustrated in Fig. 17, has the merit of being cheap and easily constructed, but if the workman desires a better tool upon the same plan he can fit a face-plate to his lathe and then get three rings made of cast-iron of the same external diameter as the plate. Fit these rings so as to be held close to the face of the plate by three bolts which pass through the outer circumference of the rings, equi-distant from each other, and screw into the face-plate. By having the holes in the central portion of these rings of larger or smaller diameter, any such work as small pulleys, plates or disks, can be held and worked with ease. In case a ring is spoiled or broken it can be renewed at little more than the cost of the cast-iron.

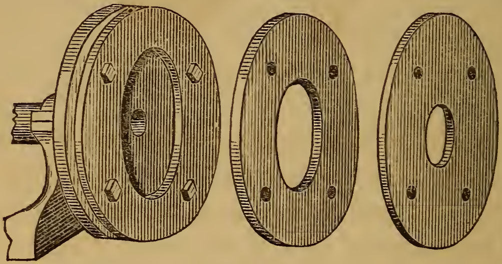

Fig. 18.

Another method of forming a chuck to hold a pulley or disk through which there is a circular or irregular formed aperture is very simple and well adapted for general work. The representation which we give in Fig. 18 readily explains it. Into a face-plate, which is fitted to the lathe, insert a steel spindle, which must be turned so as to run true; upon the farther end of this spindle cut a strong thread and fit a nut to it; then fit a cone of iron or brass upon this spindle so that there will be no shaking or vibration; have several washers or disks which also fit the spindle and are of an external diameter about the same as the base of the cone. To use this fixture to turn or face up a pulley or disk, remove the nut, washers, and cone, hold the work to be wrought upon next to the plate with the spindle through its aperture; place the cone so as to enter the aperture, which will probably be longer than the apex of the cone; place a washer or two against the base of the cone and screw the nut against the washers. As one side of the work rests against the face of the plate, the work is kept true by the cone in its central opening. This will be found an easy way of ad-

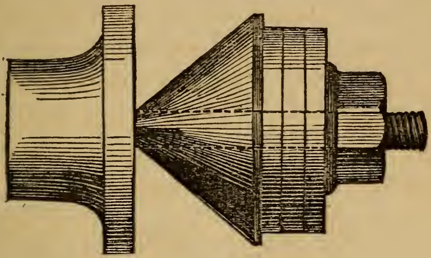

Fig. 19.

justing and an efficient mode of holding many things that need to be quickly placed in position for operation. If it be required to support the end of the spindle where the nut is fitted on account of its vibrating during the working, a center or countersink may be made in this end, in which the center of the dead spindle of the lathe may be inserted. This tool will be found a most excellent substitute for the multitude of short iron arbors which are required to be driven into the holes of wheels and pulleys in order to turn or manipulate them in the lathe.

While we are upon the subject of chucks we must not forget to mention one that is not perhaps exactly an adjunct to the iron-worker's lathe, yet where wooden disks and chucks are to be made for the purpose of holding patterns or castings to be turned, it will be found very serviceable. It is simply a plate that screws upon the lathe-spindle the same as an ordinary face-plate, as shown in Fig. 20, and in the centre of this plate is secured a short, stout, gimlet-pointed screw, which projects from the plate about an inch or so, as may be necessary. To fit a piece of plank or board to a face plate to make for instance, the chuck represented in Fig. 17, screw the wood upon this chuck and then turn the recess to fit the face-plate, and as this plate is at the time detached from the

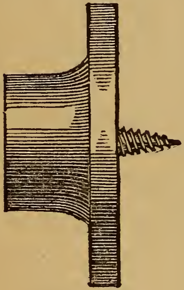

Fig. 20.

lathe the wood may be nicely and quickly fitted. Then unscrew the wood from the screw-point and fasten it to the plate by means of screws, put it upon the lathe-spindle and turn and finish up the side where the straps are to fitted. Without this screw-point chuck the board would have to be held to the plate by means of screws; the size of the plate to which it is to be fitted taken by calipers and the recess made accordingly, then the board reversed and fastened again to the plate by means of the screws and finished up to suit the work.

ECCENTRIC AND CONCENTRIC CHUCKS.

Some form of eccentric or concentric chuck is desirable in all machine shops and almost indispensable for the lathes. Of the eccentric chucks two forms have been used: the older one, in which the work was held by screws passing through lugs or ears, which projected at right angles to the face of the chuck and upon its outer periphery; the more modern tool, in which the work is held by jaws which work in radial grooves, and each jaw operated or moved independent of the other by means of a screw confined to the body of the implement and turned by a wrench. Where irregular shapes are to be held, or disks are to be operated upon otherwise than concentric with their circumferences, this chuck is invaluable, and is a standard tool. It is also used largely as a concentric chuck, the workman being aided in confining the work in a concentric manner by means of circles made upon the face of the chuck as it revolves upon the lathe-spindle. The great objection to using it as a concentric chuck is the time usually consumed in placing the work so as to revolve upon its diametrical center, and resulting from this we see the concentric and scroll chuck brought into use. Of chucks of this character we find two kinds at present in the market: one in which the jaws are moved simultaneously by the turning of a plate upon the face of which a volute spiral or "scroll" is cut, and in the indentations of this scroll the projections made upon the back of the jaws find a hold, and by the turning of the plate the jaws are moved concentric to or from its center. In the other form of chuck the jaws are fitted on screws similar to the eccentric chuck, and on the upper end of each screw a small bevel-wheel is placed, and these wheels are rotated in unison by means of a circular rack, which lays in a recess behind the jaws and is turned by a wrench applied to any one of the projecting heads of the screws which carry the bevel-gears. This chuck has an advantage over the other concentric chuck, inasmuch as the circular rack may be removed, and to all intents and purposes it is then an eccentric chuck; or one or more of the jaws may be set at any distance, by thus removing the rack and then replacing it, they will move in unison in the manner in which they are placed. It is to be regretted that a chuck of this character is not made which can operate both concentrically and eccentrically, without the trouble and time required to change this one, as to do so it has to be taken entirely apart, and then put together for use. Several years ago a chuck was invented which was similar to the concentric chuck mentioned in all respects but with the addition of a sliding ring placed in its rear, bearing upon the circular rack and holding it in place; a cam was made upon this ring for each jaw, and by turning it in one position the jaws were engaged so as to operate in unison, and by moving the ring to another position the the cams were made to disengage the circular rack from the gears attached to the screws of the jaws, and it was then free to be operated as an eccentric chuck, each jaw working independent of its fellow. It would be presumed that it was an improvement that would have been speedily adopted and much appreciated; but for some reason it was never generally adopted by mechanics, and it yet remains for some one to " bring out " this desideratum in a chuck.

With all the advantages of concentric chucks there are some disadvantages. In the first one, described and known as the "scroll chuck," the dirt and debris of the workshop will get into the recesses which form the scroll, and so clog the projections of the jaws which are received in the sunken portion of the scroll that it is incapable of further use until it has been taken apart and the obstruction removed. Sometimes in endeavoring to move the jaws by force, when so clogged, the scroll is broken and the chuck ruined. In the concentric chuck, in which the jaws are moved by the circular rack, this objection does not exist; but there is another which is of some moment, for when the screws become worn by their action through the tapped holes of the jaws, and if there be any play or backlash between the circular rack and the bevel-wheels on the screws, the positions of the work will vary according to this wear and backlash, upon its being removed and again inserted, so that the jaws grasp it in a different place upon the circumference of the work from that in which it was first held. This chuck has one great advantage over the "scroll" chuck, inasmuch as it is much lighter, being a thin shell, and only about one-half or two-thirds as thick as the scroll chuck.

It would seem that if a chuck could be made which would be light and strong, positive and firm in every movement, and with no grooves or radial slots to catch dust and dirt, and at the same time capable of being used as a concentric and eccentric chuck, without being taken apart to effect this change, it would meet with favor in the mechanical world, and enable its inventor to reap a rich reward for his ingenuity.

SAWS AND ROTARY CUTTERS.

THE employment of saws and rotary cutters in the lathe is not a very general custom, more we suppose on account of no fixtures being provided with which to hold the work to be operated upon than for any other reason. Yet many such fixtures are cheaply and easily made. The first thing to be called in requisition is a steel spindle, which may be about eight or ten inches in length, nicely made with large-sized countersunk centers to fit the centers of the lathe. One end of the spindle is turned down for a little distance so as to form a shoulder, against which the saw or cutter finds a bearing, and is there confined by a nut screwed up against it. A steel spindle like this ought to be the accompaniment of every mechanic's tool-chest.

The saws to be used upon this spindle may be made from pieces of sheet-steel, with holes bored to nicely fit the spindle, and then placed upon it and turned to the necessary size. By turning these blanks, as they are called, upon the spindle on which they are intended to be used, they will be sure to run true when at any time they are taken off and replaced. If driven upon a mandrel and then turned, some trouble may be experienced, as the thin metal has not surface enough to hold them from rotating when the turning tool comes in contact with them, or, if the operation should be successful, the saw may not run true when placed upon the spindle to be used. Sheet-steel of any thickness can be obtained from which to make these saws, and then there will be no actual necessity of turning their sides to get them true or of the proper thickness. If three or four of these pieces be drilled or bored to receive the spindle at the same time, and placed upon it in the same manner as they are to be used, they can all be turned in a little more time than it would require to make a single one, and by keeping them thus clamped together the cutting-teeth can be filed or cut at the same time with but little more labor than would be required to file or cut a single one.

One of the advantages of using sheet-steel in preference to hammered, is that, by the formation of the sheets by rolling, a uniform density is secured, and there is less danger of warping and cracking than in the hammered plates, which by unequal degrees of density, induced by unequal pressure of the blows given, is sure to be warped and distorted when it comes from the fire in the process of tempering. One word upon the subject of tempering these saws. Many mechanics find it difficult to obtain a good or even temper in the saws which are used for nicking screws and similar operations. And the larger the saw the more difficult is the operation of tempering. When the saw is ready to harden, heat it evenly over a clean charcoal fire, turning it around in a horizontal position so as to insure an even temperature—do not let it reach a heat above a cherry-red color—and when that is attained, dip it evenly, also in a horizontal position, in a pan of good quality of lard or whale oil, and let it remain until it is of the same degree of temperature as the oil, and while it is cooling gently move it back and forth, so as to bring it in contact with fresh oil. When cooled remove it, letting as much oil stay upon its upper surface as will remain there, and hold it over a brisk, clear charcoal fire, moving it so as to expose all the surface to the fire, and when the oil takes fires and *flits*, as it will, over the surface of the saw, then remove it and let it gradually cool. The oil must not be allowed to blaze, or it will leave the saw too soft to cut the harder metals. If these directions are followed with care, a good and even temper will be produced, which will be satisfactory. Thicker cutters must be tempered by drawing them to such color as may be desirable for the work as in ordinary cutting tools.

TO MAKE ROTARY CUTTERS.

THE usual method of forming the teeth of saws and rotary cutters to be used in the lathe, or otherwise, is to clamp them in the vise and form each tooth separately with a file. This is quite a laborious process, yet, by the aid of another properly-shaped cutter and a simple fixture to hold the blank properly, the cutting of the teeth can be done in the lathe and the whole filing be dispensed with, except what little may be necessary to finish the points of the teeth. In the cutter, A, to form the teeth is rotated in the lathe, and the blank B, is held in a horizontal position about the hight of

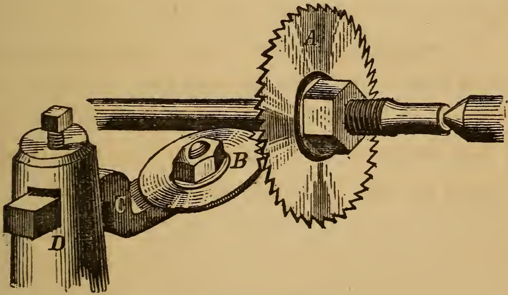

Fig. 21.

the cutter-spindle upon a piece of iron C, which is held in the tool-post, D, of the lathe. The blank is placed upon a short stud, which is inserted in C and is confined so as not to rotate by a nut which is screwed down upon it. By feeding the blank up to the cutter by means of the transverse screw which moves the lathe-carriage a cut can be taken, then run back, loosen, the nut turn the blank a sufficient distance to form a tooth, screw down the nut, run the blank up to the cutter, and a tooth is formed, and so proceed until the entire circumference of the blank is serrated. This fixture is probably the cheapest and simplest that can be made for this purpose. The divisions or distance from tooth to tooth must necessarily be made by the eye, yet for common cutters or saws it will be sufficiently accurate.

We once had occasion to make a number of small saws of a little more than an inch in diameter which were required to form the groove in sewing machine needles. As the teeth of these little saws were somewhat tedious to form, and it was a necessity that they be formed equally around the periphery of the disk, we attempted the application of the knurl or milling tool for that purpose, and upon the trial being made with a sharp and deep-cut knurl it was every way successful, and in almost a moment of time the little blanks were easily made with the necessary teeth, which only required a little manipulating with a file to properly finish them.

There is another method in which the teeth of saws may be formed. Turn and finish a hub in the same manner as hubs are formed for cutting screw-chasers, but let the shape of the spiral or screw be the reverse of the shape needed for the saw, then place the blank upon the fixture, as shown in Fig. 21, but fitted so as to revolve freely, and rotate the hub in the same manner as the spindle that carries the saw as shown in the cut. Upon moving the blank up to the hub, it will rotate the blank and form the teeth at the same time until the necessary depth of cut is taken. With this same arrangement and a hub of the proper form small geared wheels in thin metal may be quickly and cheaply made.

TO CUT A RACK IN THE LATHE.

THE mechanic may have occasion to make curved racks which are segments of circles, which may be found somewhat difficult to make, but by fastening these racks upon a disk of the same outside curvature and letting it rotate by the action of a hub the same as used for making screw cutting tools, the teeth may be rapidly made, and this simple apparatus will answer every purpose of a large and costly gear-cutter, with the advantage of operating much more expeditiously. Straight racks of thin metal may be made by means of the same apparatus, but the blank to be cut must move in a line parallel with the axial line of the revolving hub. No effort will be needed to assist the rack in passing over the hub, as the spiral lines which form its screw-like periphery will accomplish it, and as the blank passes along the teeth are cut.

If the blanks to be cut in this way should be of very thin metal then an arm or a circular support will be necessary to be placed under them to prevent the cutter or hub, whichever forms the teeth, from bending or springing the blank as it operates upon it.

We have no doubt but that this principle of cutting gears and racks might be extended, and that gears which are designed with a hollow periphery to receive a screw or worm might be advantageously formed with a hub of suitable shape. If the attempt is made to cut gears or lathe cutters of a greater thickness than one-tenth of an inch, it will be necessary to provide some means to move the blank in a vertical direction as the cutting proceeds in order to equalize the depth of the cut and consequent length of the teeth.

TO CUT OFF METAL TUBES IN THE LATHE.

EVERY mechanic knows how difficult it is to cut up iron tubes, as it is often necessary to do. The hack saw is generally used for this purpose, and much trouble is experienced in holding the tube to be cut, and there is no other appliance except the vise to hold it while using such a saw. These tubes may be cut in the lathe with great facility, in the manner as shown in Fig. 22. Select a piece of iron about the width and hight of the recess in the tool-post, and drill a hole through one end of it of a size to receive the diameter of the pipe. Insert this piece of iron in the tool-post in the same manner as a turning tool is placed, but with the hole upon the inner side or next to the saw. Insert the pipe in the hole, as shown in the engraving, and run it up to the edge of the saw, and steadily feed it until the tube is severed; then run the tool-post back, push the tube through the hole the length you wish the next piece to be, and cut it off as just stated. This will be found a ready means of cutting up ferrules for tool-handles, and the same apparatus can be applied to cutting off small rods of brass or iron. If the tube or rod has a tendency to rotate by the action of the saw, a lathe-dog can be placed upon its extremity, and it can be readily held in place and kept steady with the hand. It is almost unnecessary to add that a less velocity of the saw must be adopted for iron than for brass, and it will be necessary to lubricate the teeth of the saw with oil while it is cutting iron, but for brass no oil will be needed.

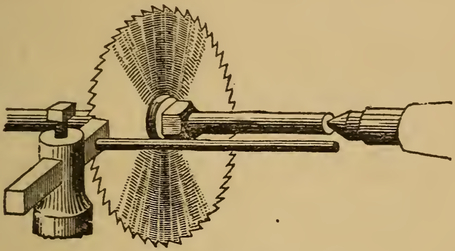

Fig. 22.

NICKING SCREWS IN THE LATHE.

ONE example of the use of circular saws or cutters in the lathe is the nicking of screws and bolt-heads ; and an appliance to hold screws for ready manipulation represented in Fig. 23, is made by inserting a block of iron in the tool-post of the lathe in a line with the axial line of the spindle which carries the saw. Upon a projecting end of this block is attached a lever at a right angle with the spindle. This lever which is hung upon a pivot and held in place by a nut, is capable of an oscillating motion. The end of the lever which projects towards the workman is sufficiently long to answer the purposes of a handle and is used as such, and the end nearest to the saw is drilled for the

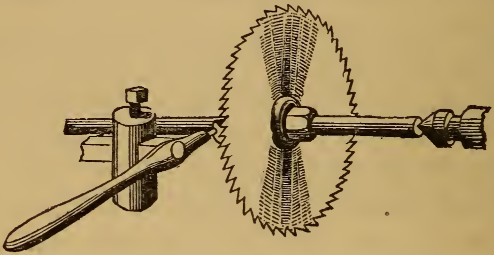

Fig. 23.

reception of the screws to be nicked. The body of the screw being inserted in the hole, it is prevented from further entrance by the projecting shoulder of the screw-head, and then, by lowering the handle of the lever, the screw is passed vertically across the teeth of the saw, which cuts the nick to the necessary depth. It may be observed that it is essential that when the handle of the tool is in a horizontal position it must be of the same hight as the saw-spindle, or the screws will be nicked deeper on one side than on the other.

A pair of tongs similar to a pair of blacksmith's tongs, and attached to the block by an extension which constitutes the part of the pivot that holds the tongs together, forms a very good arrangement for holding screws for nicking, and has an advantage over the lever, inasmuch as the screws can be tightly held and will drop from their places when nicked, by simply opening the jaws of the tongs.

We once had some screws the heads of which required nicking, and, with the exception of the saw and its spindle in our tool chest, there was no means or appliance by which to accomplish the work. The emergency of the moment would not admit of tools being made. We straightened out the arm of a small wrought-iron lathe dog or carrier, and by inserting this arm in the tool-post of the lathe with the open end of the dog toward the saw, we could insert the screws in the aperture and confine them with the binding screw, and the nick was easily cut by running the tool-post back and forth and consequently carrying the screw-head under the cutting edge of the saw. The operation was simple and easily accomplished. Other and more costly appliances are used for this purpose, but those we have mentioned furnish the most simple and easy one that can be made.

DRILL-CHUCKS.

THE common lathe and drill-press are the means usually employed for rotating drills; but in the machine-shop of somewhat limited means the work of drilling is more generally performed in the lathe, the upright drill-press often being considered a superfluous fixture. As a ready means of holding the drills in the lathe, a chuck is made that will fit into the lathe-spindle in the same place and in the same manner as the lathe-center is fitted and held. The shanks of the drill are made either square or round. The former form was once the only method used for large drills, but now that mode of fitting is nearly obsolete and the round shank is employed instead, and the drill is confined in the chuck by means of a set screw. It is quite necessary that the drill shanks should nicely fit the hole in the chuck, and a gauge is necessary to turn these shanks to the proper size. Fig. 12 shows a very convenient gauge for such purposes. The aperture A, will give the circumference of the shank when it is in course of manipulation; and when the shank is inserted into the hole B, it will indicate if it will be received in the hole in the drill-chuck, provided the diameters of the gauge and chuck apertures agree or correspond with each other.

The best form of steel from which to make drills to fit this size chuck is the octagon, and of a diameter a little larger than what the round portion of the shank is to be when it is turned to fit the chuck, and an inch and a half is long enough to make the shank. A flat surface should be filed upon it for the purpose of giving the set screw a firm seat so as to retain the drill in place when it is operating in the metal which it is designed to penetrate. A somewhat better method is to make a countersink, in which the point of the set-screw enters. This will hold it very firm with no fear of its giving away.

An easy method of getting the exact size of drill shanks, after they are roughly turned up, is to run the shank into a "hollow mill" or "butt mill," which revolves in the lathe and is made by drilling in a steel cylinder a hole of the same size as the drill-shank is required to be; make a series of cutting lips upon the end extending from the hole to the circumference of the cylinder, then, when this tool is tempered and the drill-shank forced into the aperture, the lips will nicely "shave" away any superfluous metal. By using a little care the entire superfluity of metal may be removed to the exact size without the application of the turning tool.

We have seen mechanics somewhat puzzled in attempts to produce a drill-chuck which when the shank was inserted in the lathe-spindle would run perfectly true, so that when the drill was inserted the point of the drill would be exactly upon a line with the axis of the spindle. Their method of making a chuck was to turn up the chuck and then to drill the hole for the drills or perhaps drill the hole and then turn the chucks afterwards, using the hole as a center or countersink. But this is not the proper way to proceed. Drill the hole first and make it exactly as you wish it to be when finished. Then fit a piece of iron into the place where the lathe-center is fitted, have this piece project long enough to reach the bottom of the hole in the chuck when the piece is turned down and the chuck is driven upon it; rotate the chuck after it is driven on, and at the *exact center* of the rotation of the opposite or shank end there make the countersink upon which it must be turned up. A little reflection will give the philosophy of this method of doing it, for if the unfinished chuck runs true upon the piece upon which it is driven it will certainly run true when finished in the drills inserted in the hole in which the iron was inserted.

As the shanks of many kinds of chucks and similar tools which are inserted into the holes occupied by the lathe centers are turned up with a regular decreasing diameter towards the end, they will fit the aperture in the lathe-spindle to a greater or less degree of insertion, according to their size. If it should happen that a chuck of this kind should run a little out of true, it can be remedied by draw-filing the side of the shank which describes the circle of untruth towards the small end of the shank, and perform the same operation with the opposite side near where it enters the spindle. We have seen drill-chucks that run very much out of the required circle put into place by this simple method when any amount of hammering or bending would never true them.

The best form of drill-chuck is made to screw upon the end of the lathe-spindle the same as the face-plate, and removed when the face-plate is required to be put upon it. Fitted in this manner the chuck may be of cast-iron, and if it be subject to much wear it can be easily case-hardened with bone-dust or prussiate of potash. The former is preferable. To make this cast-iron chuck, if there be no other means to hold it, place a piece of plank or board upon the face-plate of the lathe in the same manner as the chuck shown in Fig. 17 is fastened, turn a hole in the center of this piece of wood as it revolves, and when of a sufficient size drive the casting into the hole; let it revolve *without* any support from the outer end, then face off this end, center it, drill the necessary sized hole, cut the screws inside to fit the lathe-spindle screw, and when thus far finished remove it from the wooden block, screw it upon the lathe-spindle, and then finish up the outside and drill the hole for the reception of the drill-shanks.

This chuck is very strong, is not easily broken, and remains rigidly in place when the drill is employed and in situations when the shank-chuck would be turned around, to the detriment of the lathe-socket, by too great a pressure being applied to the cutting-power of the drill.

It is much better to attach fixtures to the lathe-spindle by means of the screw than to insert them in the socket where the turning-center is placed. It is necessary that this center should *run true* at all times, and when drills and chucks are inserted in its place, evil results may follow by their marring the surface of this aperture, and the consequent rotation of the lathe-center out of a line with the axis of the spindle will be the probable result.

DRILLS.

THE drill is a tool which performs a very important part in the workshop economy, yet, strange to relate, it is the tool upon which the least care and attention is bestowed, and its form and fabrication is considered of but secondary importance. We have seen drills in some machine-shops, and that, too, in shops where good work was produced, which were not drills, but poor apologies for that useful tool. The time has been when almost any form of steel, flat, square, round, or octagon, would do for drills, and the forging and finishing up of the drill would be a matter of as little consequence, and with this most miserable abortion of a tool, good work and nicely bored holes were supposed to be made. That the holes were made is very true, but what degree of truth, nicety, or accuracy, no comments are needed or required.

The machine-made twist drills are fast superseding the flat drill, aud where they are once introduced into a machine-shop they are preferred to all other kinds. Let any mechanic compare the *cutting edge* of the flat with the twist drill, and the superiority of the latter will be apparent. The flat drill presents a *scraping* edge to the metal to be penetrated, while the twist drill has a *cutting* angle which very nearly approaches the form of the cutting edge of the lathe tool. When these two tools are used in cast-iron it is observed with what ease and rapidity the twist drill penetrates, and when used in wrought-iron or brass, long and extended spiral chips will follow up the twist drill groves, showing that it is indeed a *cutting* tool; when if the same effort be made with the flat drill in the same material, no such spiral chips are the result, rough fragments of the metal being *forced* off, which shows that it is nothing more or less than the effect of a *scraping* process. It requires a nicely made flat drill to produce as true and smooth a hole as even a badly made twist drill will execute.

We have given directions in the chapter upon gauges, callipers, etc., how to make and finish the shanks or drills, and we recommended the octagon bars of steel from which to make them, and of a diameter of a half inch to correspond with the gauge which we have there shown. We have always found it advantageous and economical to cut up bars of this sized steel into lengths of from six to eight inches and then turn up the shanks and fit to the chuck a dozen or two of these pieces at a time, and then they are ready fitted to be made into drills whenever occasion requires. If the drills are the size of the steel, they should be when drawn down at the forge of an average length of about eight inches. This length is a good proportion and better in practice than either a longer or shorter drill. If it be required to make a round or twist drill, it is convenient to take one of these pieces and turn the body to the size and then fashion it to suit the work.

The flat drill should not only be flat at the point but have its body also flat, so that the chips or borings may be carried around with the rotation of the drill and not be ground between its sides and the metal which the point is penetrating. The cutting point must be made thin so as to more easily penetrate, and in process of working this point must be kept thin and sharp, otherwise a ragged hole will be the result. The form of the point of the drill should be such that the two lines should meet at 90°, or, what is more explicit, exactly fit the inner angle of the fitting or try-square, which is an angle of 90°, or one-fourth of the circle. There is another advantage in shaping the points of drills in this way with the square; a measurement from the body of the drill to the arms of the square, when the square is applied, will give an index of the proportion of the lines of the point as regards their equal length, and this measurement is easily ascertained by the eye. This exactness is important in a good cutting drill, as both sides must perform their proportion of the work. The *cutting* angle should meet the face at 60°, but a variation may be made in regard to this according to the hardness or other characteristics of the metal to be penetrated; a harder metal requiring less acuteness of

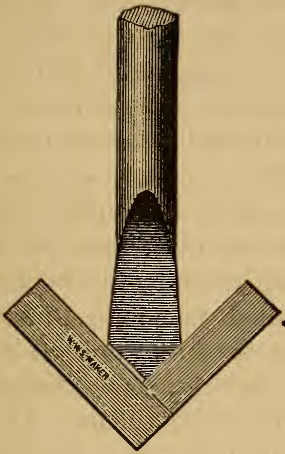

Fig. 24.

cutting angle. When the drills are dull and are ground, let the same gauge which is shown in Fig. 24 be applied to ascertain the form of point.

Another method of using the drill is to insert the back or dead center in the countersink at the end and hold it fast with a wrench, and apply it to the work which rotates in the lathe chuck or some other fixture. These drills may conveniently be made of bars of flat steel about eight inches long and of a width and thickness to correspond with the work. The center or countersink which is to enter the center of the lathe should be made large, so that there will be no danger of its slipping out of place if it should be found necessary to slightly turn the center back, as is often done to free the drill from clips. We have seen old files used for these drills, and also seen old files drawn down to make common flat drills; but we must express a hearty contempt for such a slovenly method of producing a tool, which when made may well be regarded with disgust by every mechanic of taste who has any pride in the appearance or working of his tools.

The step from the old fashioned flat drill to that of the improved twist drill, is one of the boldest leaps in mechanical science, and may be compared to a single stride from a tool of an ignorant age to the finished implement of the enlightened period. When we take a look at their forms and compare them, we see at a glance the imperfections of the flat drill and the superior qualities of the twist drill. In the flat drill, as it revolves in the metal that it has to penetrate, it *forces* a portion of the material before it by a direct action, rubbing it off, as it were, by the applied power; the cutting lip presenting an edge at a right angle with the work. Give a lathe tool to a mechanic, with the same form and angle, to "turn up" a piece of iron work, and if he understands the nature of the material he is to operate upon, he will throw the tool from him as if you had offered him a premeditated insult. He knows very well that there is no "cut" in that form of tool. It may, by *abrasion*, reduce the work upon which it is employed, but it will not cut it. But give the same mechanic a drill made with the very same angle of cutting lip, and he will use it in his work with no feeling of a detraction of his dignity. He probably never gave a thought to the *effect* of the form of the cutting edges, as presented to the resisting metal. He knows the best shape of a good turning tool, and his experience tells him that the point of the instrument *must* run under the metal like a wedge, and *lift it off* as the cutting point advances, and not *scrape* it away by direct applied force against the *resisting face*—not cutting edge—of the tool.

Show a twist drill to the mechanic, and compare the cutting angles of the two instruments, and he will readily see that the cutting lip of the twist drill is almost an exact form of his well-made turning tool. In operation he will observe that, instead of the abraded chip of the flat drill, it will be a clean and smooth-cut ribbon of the metal that is thrown up the spiral grooves of the drill as it penetrates into the material. The peculiar advantages of the twist drill are not generally known throughout the country; but where they are once introduced they are soon appreciated, and applied to the exclusion of the flat drill. Some of the advantages of the twist drill are that it will always bore a hole that is perfectly cylindrical, when the flat drill will not always do this. The ease with which a twist drill cuts is another recommendation, and the strength of them, compared to the flat drill, is still another good quality. When the twist drill is broken, it can be easily put in order at the grindstone, if it has been properly made, and will operate as well and be of the same size as when first employed.

Twist drills, although they are a recent article of commerce, are not a new form of tool. They have been used by the manufacturing gun-maker and the sewing-machine workman for the past twenty years; but their application beyond these certain trades has been very rare until within the past five years. Now their use bids fair to become general. The introduction of them also tends to greater accuracy of work, as well as a step toward a system of sizes of gauges in forming holes, as the manufacturer of twist drills make them of the different sizes of steel wire, or increasing by the divisions as marked upon the standard inch, and the mechanic must necessarily form his bolts and turned work to fit these holes with some degree of accuracy.

TWIST DRILLS.

THE flat drill is quickly and easily made. The twist drill requires time and some skill to form. The flat drill can be made larger by *spreading* the cutting point by means of the forge fire, but the twist drill once made is a tool of a constant size ; it cannot be enlarged or reduced without spoiling it. So we see why, in many shops where miscellaneous work is done, the flat drill has the preference, but in shops where gauges and constant sizes of work are made and expedition is a requisite, the twist drill may be used to great advantage.

Within a few years the manufacture of twist drills has become an established business, and any one wishing such drills can purchase them at the stores where tools are kept and sold. Some of these drills increase by the sizes of the wire gauge, so that the holes made will fit the wire purchased if such a fit should be needed. They are also made to increase by sixty-fourths of the inch, but as an improvement on those sizes we would recommend that they be made of sizes increasing by the decimal divisions of the inch, or by tenths and hundredths, etc. As it is customary in some places and more particularly on what is known as "government work," to "lay out" work by the decimal divisions and in prospect of this division measurement becoming a standard, it would be no more than just that these drills be made by these divisions, and when made have their sizes marked upon the shanks.

The larger sizes of these drills as manufactured have taper shanks which are inserted in chucks made to fit the lathe, but the smaller sizes are not thus made; the shanks are of cylindrical form, of the same size as the drill, and, as they vary thus, small concentric chucks are needed to hold them when used for drilling. Several forms of these chucks are easily obtained from the same source as the drills.

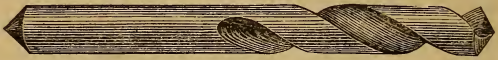

Fig. 25.

If the mechanic desires to make a twist drill for himself, there are two methods by which to accomplish it—by forging or by cutting it from the solid metal. A good drill may be formed by either method. One thing must be borne in mind: if too little twist be given, it will approach too near to the flat drill and will be but little more effective than that form; while, on the other hand, if too much twist be given, the cutting edge presented will be too acute—breaking or crumbling away before the resisting metal. Some years ago, a manufactory employed one of its workmen to make a set of costly twist drills which were intended as standards of size for the series of holes in a sewing machine; but unfortunately the mechanic who made them formed them with too much twist, and the constant breaking of the thin cutting lip and the difficulty of keeping them in order gave twist drills a bad repute, and they were thrown aside. We mention this as an instance of a fault to be guarded against. Better make them too straight than too much twisted.

If it be required to make a drill from the solid metal, let the mechanic turn a cylinder of the size he wishes the drill and then with a small round file cut out and finish the grooves. We must admit the round file is not just the tool to do this with; a flat file with round edges is better, and to prevent the teeth on the flat surface from spoiling the sharp edges of the grooves which are to be retained it will be necessary to grind the flat sides of the file upon a grindstone until the cutting edge of the teeth is destroyed.

To form a twist drill by forging is more difficult. It is necessary to forge a flat blade similar to a flat drill and then twist this blade into the semblance required; then, with a light hammer and careful blows, hammer the twisted edges so that they will be thicker than the central line of the tool. This will give greater strength and a better drill, and to cut well, the central line or cutting point must be made quite thin. Be careful to get the *same twist* at the point of the drill as upon the body of the drill. We mention this as the inexperienced often leave the point *straight*, with no twist, like a flat drill.

When the drill is forged there are two ways of finishing it up:—By turning it true and of a proper size in the lathe, or by running it into a "butt mill" or "end tool," which is represented in Fig. 26, and consists of a cylinder of steel with a hole made through it of the size that the drill is to be, and with teeth cut upon the end of the cylinder which is to be presented for the entrance of the drill forging. When the tool is thus made it is nicely tempered. To use it place the forging for the drill in the chuck where it is to rotate when used, then hold the tool with a wrench or any convenient mode of retaining it and enter the point of the drill as it revolves in the chuck and forcibly press the drill into the aperture of the mill. The cutting teeth of the "mill" will form the drill of a true cylindrical form. It may be necessary to form the forging like a V at the point, so that it will readily and centrally enter the hole of the mill, and while it is cutting away the surplus sur-

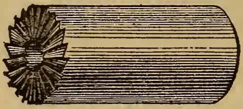

Fig. 26.

face, oil must be supplied or the delicate teeth of the tool will be destroyed. When the drill is thus "sized," as it is termed, remove it from the lathe and file it up as before described, and temper to suit the purpose for which it is needed.

Twist drills are now made a special manufacture by some concerns, who furnish them at such prices that, unless to fill up spare time, it will be hardly worth while for any machinist or other mechanic to manufacture them for himself.

BORING TOOLS.

Boring tools are employed to enlarge holes which have been previously made by means of the drill or casting aperture by means of cores. A drill of larger size than the existing holes is often used for the enlargement of such holes, but unless some extraordinary circumstance demands it, this method will not be used or tolerated by a workman who calls himself a good mechanic. As the drill has no central steadying point on which to revolve, it cuts in uncertain circles, and as it removes the metal it chatters and trembles, and when it has completed its work the result is a polygonal aperture of which even a raw apprentice ought to be ashamed.

A very good tool for enlarging holes is the one here represented, which is termed a "counterbore," or "pin drill," or, as it is called in some shops, a "sweep." The tool is fitted to the chuck in the same way as the drill and is held in like manner by the shank; the opposite or cutting end is flattened and turned to a diameter exactly of the size of the hole required. This flat portion may extend up for two inches or more toward the shank. At the end where the tool enters the metal a "tip" or "pin" is made, which must be turned of the same size as the existing hole it

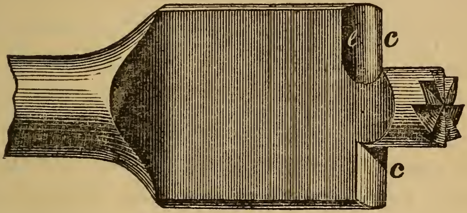

Fig. 27.

must enter. The cutting lips, *c*, *c*, of the tool are sloped back with a file so as to form a cutting edge, of about 60°. On the advancing edge or side, a recess, *e*, is hollowed with a small round file so as to give the cutting lip more of the form of a cutting tool. The end of the tip is serrated or cut with teeth, so that if the tip should bind in the hole as the work progresses, their serrated edge will cut away the metal which would otherwise bind, and it will be permitted to pass easily and free through the metal. A set of these tools ought to be as much of a standard as reamers and made of similar standard sizes. In a dozen of these tools made of as many different diameters, there need be only about three sizes of tip, so that that number of twist drills will form a hole ready and accurate to receive the tip. One word of caution to the mechanic. The hole in which the tip is to work must be of the *same diameter* as the tip in order to so steady the cutting-lips of the tool that a hole perfectly true will be the result. This tool works ready and rapid when properly made and gives very good results.

The counter-bore proper is a cylinder turned of the required size of the hole it is to produce, with a tip formed similar to the tool we have just described, and the cutting edges, which should be three or four, formed by circular grooves of a twist drill. This tool is much stronger than the flat counter-bore, and will cut much steadier; it is more costly to make, and unless it is wished for a standard size of hole, of which a larger number are required, it is seldom made. It is commonly met with in the rifle factories, in pistol shops, and is also used in the manufacture of sewing machines.

Another form of boring tool may be cheaply made by turning a steel rod and fitting it to the chuck in the same manner as the drill, then make a mortise through the end opposite the shank; in to this mortise insert a detachable blade or cutter, and confine it by means of a key driven in above the blade. The tip may be serrated in the manner as described for the flat counter bore, and made so that it will fit the drills as used with that tool. About three of these rods so fitted will be all that will be needed for small work. The cutters of course may be made of any size that is needed. If a bar of steel be purchased of the thickness and width proper to make these cutters it may be annealed, and by cutting off pieces with a hack-saw of the length of the diamater of the hole to be made, much labor will be saved.

If it be necessary to bore out a hole with this tool and the tip be much less than the hole, a ring or collar made of iron, brass, or even wood, may be made to fit the hole and placed upon the tip, and it will be found to work quite satisfactorily.

There is another tool which is much used in some shops and is admirably adapted to form smooth and nice holes, and it operates as well in large holes as in small ones. It may be used either in the chuck like a drill or placed against the dead-center while the work is revolving and urged into the hole by means of the tail screws of the lathe. Make a blade of steel thick enough so that it will not twist or spring in the work, turn the edges nicely and also square up the end, but somewhat round the angles of the corners and fashion the cutting edges. When it is thus made, place two pieces of hard wood one upon each side of flat surface, and fasten them in place by means of two screws, which pass through the wood and steel blade. The wood must be turned and shaped of the same diameter as the steel blade. In operation the wood follows the cutting edge and serves to keep the advancing edge steady, and holds it true to its work. It is an excellent substitute for the reamer in holes and for boring out work where the apertures are too large to enable the reamer to be made and used to advantage.

In the boring tools which we have mentioned the "tip" or entering portion must follow the hole previously made, and the tools are commonly rotated in the lathe by being inserted in the lathe-chuck and the work held against the dead-spindle which is forced forward by the tail screw, the work advancing as the tool cuts away the metal presented for its action. The operation may be reversed and the work rotated in a chuck attached to the live spindle and the tools may be held against the dead-center, which is advanced, the tool being kept from rotating by the force of the cut by attaching a dog or driver to the shank of the tool and letting the arm of the driver rest against the lathe-shear.

THE BORING BAR.

We have given examples of boring tools which are designed to follow a hole previously made, enlarging it to a size corresponding to the diameter of the tool, cutting out a circle of the metal of equal thickness upon all sides. It is often found necessary to remove portions of metal of which the previously made hole is not the center of the circle which the tool is to traverse, and the methods used are entirely different from those previously noticed. An implement called the boring-bar is the tool used for this purpose.

To make the boring-bar, select a steel or iron rod of suitable length and diameter. For the general jobbing-shop about two feet in length and an inch and three-quarters or two inches in diameter will be found suitable. For longer work of course a longer rod must be used, and for a smaller hole than two or two and a half inches a smaller rod is necessary; but for holes of less than two inches diameter, unless it be necessary to bore them eccentric to their circumferences, the boring tools already described may be more advantageously employed. Having selected the bar, proceed to square up its ends and center them to correspond to the form of the center of the lathe, and be sure to make the centers very deep, so that the springing of the bar or a sudden interruption of its course will not cause it to fly out from between its bearings as it turns upon the lathe centers. When the bar is turned true and nice, make a suitable mortise, of the form of a parallelogram in the central portion of the bar, in which to place a movable cutter, and form a gib or key to drive in behind the cutter so as to hold it firmly in place. These cutters must be made of the size of the intended hole, and may be formed with cutting edges at each end, so that one end will remove the rough chip and the opposite end will produce the finished surface. The form of these cutting points will be fashioned by the mechanic to best suit his ideas of a cutting tool, and as they operate similar to a lathe-turning tool, the hint may perhaps not be lost in mentioning it.

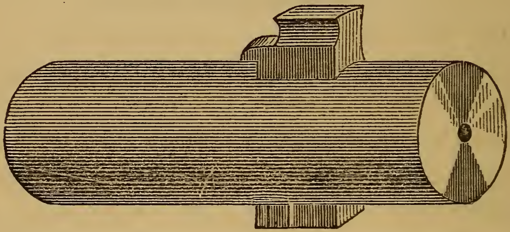

Fig. 28.

Preparatory to using the boring bar, the first thing necessary is to ascertain if the lathe be set so as to turn a true cylinder or a cylinder of the same size at each end. To do this, take a rod of about two feet long, place it in the lathe and turn an inch or two at one end, reverse the rod and run the tool and carriage to that end to ascertain if the poiut of the tool corresponds to the cut made; if so the lathe-centers are "set true"—if not, move the tail-block "in or out" until they are so, as may be ascertained by trying the rod.

The next operation is to place the work, supposing it to be a small engine cylinder, upon the lathe carriage, as the work must move in a horizontal line while the tool performs its rotary motion. A piece of hard-wood plank may be fixed to the lathe carriage by means of bolts and the work may be secured to this piece of plank. The means of fastening it thus will best suggest themselves to the workman. After this is done insert the boring bar with the cutter ready fixed, and see that the bar is snugly set, but not too tight, upon the lathe-centers; it must be free to turn, yet not bind. To ascertain if the tool will cut the desired circle, revolve it slowly close to the work and note the circle it makes, then remove the work, by raising or otherwise, until it is as desired. The opposite end of the work may be tried in the same manner. See that all is made fast and correct, and then run the work up to the cutter, throw the feed into gear, and let the cutter begin to operate.

During the first or rough cut the bar will spring somewhat and the surface of the hole will be marked with the "chattering" of the tool; but to finish the hole a second cut must be taken, using another tool of a larger diameter than the first one, and use it with a faster speed and a moderate degree of feed force. It requires a little experience to use this tool, and we would recommend to young mechanics to observe the "modus operandi" of older and more experienced workmen and make a note of what they see, lay it by until they are called upon to do a like piece of work, then perhaps a trifle of showing from some one who is expert may be all the help they require.

Where a boring bar is to be used for a succession of holes of about the same size, an iron disk may be fixed to the bar about midway between its ends, and mortises made in its periphery in which the cutters are inserted. The cutting edges of these cutters should be about 60°. We would recommend three, five, or seven as the proper number of these cutters, according to the size of the disk. An odd number of cutters work steadier in the metal they cut away than an even number. For small holes three are sufficient. The projection of the cutting edge beyond the disk need not be more than one-fourth or one-half of an inch. When taken out to be sharpened, small pieces of card or writing paper may be inserted at the base where they rest in the recess of the disk to compensate for the surface reduced by grinding. By holding a point tool near them as they revolve it will be easily ascertained how much packing is necessary to bring them to form the required circle of rotation.

Where work can be chucked or made to revolve upon the face plate of the lathe, as pulleys, etc., a ready means presents itself of using the turning tool as it is set in the tool-post, and the feed of the lathe to move it forward to bore out the hole as wanted. One difficulty in this method is that the turning-tool must be made so long and slender that it is subject to much spring and chattering, and the result is not at all times as good as desired. With the exception of holes of no great depth, we regard it as a poor method of forming a hole. Better by far use the boring bar, the reamer, or some of the other forms of boring tools as described.

REAMERS.

When the flat drill is used to make a hole, so little confidence is placed in the result that it is generally taken for granted that the hole produced is neither straight nor cylindrical; and the reamer is introduced to finish what the drill did not produce.

Many forms of reamers are made and used. We have seen flat bars of steel, made slightly taper, and then tempered for use. Such an implement may enlarge a hole to a certain diameter, but it is a tool that no good mechanic will willingly use. It operates about as accurately to produce a true cylindrical hole as the flat drill. The square reamer is used in many shops, and is but little better than the flat one. The right-angled corners which are presented to enlarge the aperture are not "cutting angles," but are "scraping edges." Give a tool with the same form of cutting edge to a workman to *turn* an iron spindle or turn out a hole in an iron plate, and he will throw the tool away in disgust, and make one which will have a cutting edge of a more acute angle; yet this same workman will, perhaps, employ the square reamer, and think no better form is needed.

Another kind of reamer is made of a half cylindrical form, and is a great improvement upon the flat and square shaped tool. Its cutting edges are more of the form of a cutting tool, and when pressed up to the work it takes a rank hold and tears out large chips. In rough work, as boiler plates, or fitting sheets of metal together, or reaming out holes which have been made by means of cold punching, or at the smith's forge, perhaps no better tool could be employed. It also has the merit of being cheaply made, and is strong enough to bear rough usage, and another advantage, it can be easily sharpened by grinding it on the flat side upon the common grindstone.

For small holes, as in clock and watch-work, small pentagonal and five-sided reamers are used, which are purchased at the hardware stores. These reamers may do very well to smooth out a hole, and in thin material will enlarge a hole sufficiently; but for holes of any length they are of but little use if the hole is not true and straight, for if the hole be of any great length and crooked, the reamer will produce an oval rather than a round hole. Reamers of this form have no place in the machine-shop.

The best form of reamer in use is the fluted one. To make it, a cylinder of steel is turned in the lathe, and the blades are cut out of the solid metal either by a planing or milling machine. In the former case a reciprocating tool is moved over the surface of the cylinder, and in the latter the cylinder is moved under a rotating circular cutter. One fault in making these fluted reamers is that they are often made with too many teeth or cutting edges, and the hole produced is not of an exact cylindrical form, but looks as if composed of angles which form a polygon. We have seen these reamers with upward of a dozen cutting lips; but better work can be done if they only contain about five or seven cutting edges.

One form of reamer may be made cylindrical with a single lip, and it is capable of producing a very nice hole, but does not work so expeditiously as the many-lipped reamer. It is made by turning up a cylinder of steel of the required size, and then plane or mill a round groove the length of the cutting portion; one side of this cut forms the cutting edge; then plane away the opposite side about half way around the length of the cylinder, and when the cutting lip is filed up it is ready to be tempered for use.

Another form of reamers are called *rose reamers*, or *rose heads*, and they are used for enlarging holes that have been cored out, and cannot be enlarged otherwise except by chucking the work and turning out the hole. These reamers are generally made of short cylinders of steel, with a hole through their centers, into which an arbor or spindle is fitted, and the face or end of the cylinder presented to the work is cut with numerous teeth.

As the corners of the teeth are apt to wear and become injured, it is best to turn off a portion of these corners in the lathe and make the cutting lips to extend across the angle so produced and a little way up the side of the cylinder. One disadvantage in the use of this tool is, that when the edges of the teeth are worn, where they extend upon the side of the tool, it is apt to bind in the work.

With this last kind of reamer quite large holes may be produced of a true cylindrical form. With proper cutter-heads, or heads in which detached cutters may be used, so that when worn or broken they may be replaced, the largest cored holes may be bored out. They work much faster than the boring bar or the single turning tool, and we believe that there is no limit to the size of hole in which they may be employed.

TO CUT OR GROOVE REAMERS, TAPS, &c.

It is often found necessary to cut the groove in reamers, rose-heads, taps, etc., and in those shops where the planer and milling machine have not yet found a place, the file is resorted to and often the assistance of the cold-chisel is brought into requisition ; but the whole process is tedious and one that the mechanic dislikes to perform. When these reamers have long taper shank or shanks of a constant size, intended to be inserted in the spindle of the lathe or the drill-press, this shank can be fitted to a simple appliance and the necessary grooves can be cut in the engine lathe.

This apparatus is illustrated in the accompanying engraving, and it consists in an iron casting about six inches long, three inches wide, and about the

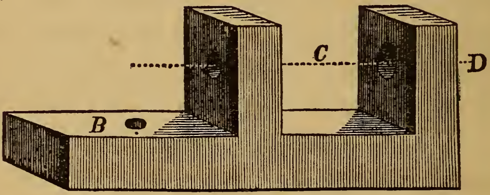

Fig. 29.

same in hight. This casting is made fast to the tool-post block of the lathe by a bolt, the head of which is retained in the slot usually occupied by the base of the tool-post, the body of the bolt passing through the hole B, and a nut upon the upper end holding it securely in place. Through the two upright projections of this casting are made the holes seen upon the line, C, and these holes must correspond to the form of the shank of the reamer. After the reamer has been turned, the shank fitted to the socket it is to occupy, and the other extremity is ready to be cut, remove the tool-post of the lathe and attach the casting in the manner just mentioned, insert the shank in the holes, letting the end to be cut project at D, and a light blow upon this end will fix it firmly in place. Then, with a suitably-shaped cutter revolving between the lath-centers, and by raising the back end of the lathe-carriage until it is of sufficient hight for the cutter to form the necessary groove, the blank is run under the cutter and a nice groove is the result. A light blow upon the end of the shank of the reamer frees it from its place, when it may be turned the proper distance for another groove or to form one tooth, and another cut is taken.

These divisions may be made by the eye or they can be marked by means of a pair of callipers, and scribed lines drawn, which can be easily followed with the cutter. These divisions can be made tolerably accurate in the lathe after the blank is turned and before it is removed, by taking the teeth of the large geared wheel of the back-gear arrangement as an index and scribing longitudinal lines upon the reamer by the aid of a rest used as a ruler, turning the wheel a certain number of the teeth and then retaining it and scribing the line, and then turning it and scribing again. We remember once fluting some reamers by holding them in the tool-post similar to the turning-tool, and supporting the projecting end to be cut with a block of wood. But the apparatus we have described is probably the cheapest fixture for this purpose that the mechanic can employ, and it is best adapted to that class of reamers which are made with a long and tapering shanks; but if the shanks are straight a set screw inserted in one of the projections of the casting will be needed to retain them in place.

It is often necessary to cut screw taps and similar tools which have no long shanks, and a fixture can be made consisting of a casting with an upward projection at each end, and of a distance apart sufficient to take in the tool to be cut, and of a hight sufficient to enable the cutter to reach the requisite depth upon the tool, which is supported upon two centers, one on either end. This fixture is to be bolted to the lathe-carriage in such manner that it can be run back and forth with the carriage under the cutter, and the groove can be thus very easily made. The exercise of a little ingenuity will enable the mechanic to cut mills, reamers, or rose-heads of almost any form and with such precision that but little filing will be needed to finish them up for use.

A different form of this principle which we have illustrated may be made applicable to cutting gears as well as mills, by inserting through the holes of the line, C, a fixed spindle having at the end, D, a shoulder against which the work finds a bearing and is retained by a nut To the opposite end of the spindle is fastened a small index-plate, and a catch is applied to enter the divisions of this plate, retaining it at any one of them while the cutter is operating on the blank. We must admit this is a comparatively imperfect substitute for a gear-cutter, yet when access cannot be had to a tool of that kind, as is often the case, such a substitute will in many cases serve a good purpose.

A GEAR-CUTTING ARRANGEMENT.

Unless the cutting of gear-wheels is made a specialty, the services of a gear-cutter in the machine-shop are not often requisite. The mechanic of limited means, whose occupation is "jobbing," as it is termed, which implies that work of all grades and kinds, and often of a nondescript character, is a "specialty," and the model-maker who works in metals, often wish for the assistance of a gear-cutter, yet the number of times which it would be used are so few that it will not pay to expend any great amount of money for such a tool. Yet if some simple arrangement be made that could be easily and quickly fitted to the engine lathe, and answer every purpose of a gear-cutter, it would be acceptable to every machine-shop where there is no gear-cutter, as it would be useful not only for cutting an occasional gear, but also the rotary cutters to be used in the lathe and milling machine.

It is seldom that wheels of a greater size than a foot in diameter or less than an inch are required to be cut, and the arrangement we show in Fig. 30 will accomplish it, and the fixture can be made at a comparatively small expense. The base, A, is made of cast-iron, and is intended to be bolted to the tool-post block of an engine lathe, or it may be attached to a slide-rest, and used in a hand-lathe. In either case the tool-post must be removed, and the head of a bolt, fitted into the recess occupied by the tool-post, has its body inserted into the hole, B, and a nut screwed upon the thread of this bolt holds the fixture firm in place. Within the upright, C, which is a part of the casting, A, a longitudinal slot or groove, D, extends nearly its entire length, and fitted transversely upon this upright is another casting, E, which is fastened by means of a bolt to C. By the arrangement of the slot, D, this casting can be raised or lowered to suit the size of gear or depth of groove to be cut. It can also be turned upon the bolt as on a pivot, and so fastened at an angle, and a bevel or a miter-wheel can be cut as readily as a straight one. The casting, E, is drilled at each of its projecting end-pieces to receive a shaft, F, which is fitted to revolve in its place, and the end which will be presented toward the cutter is made to receive the blank gear, which is fitted upon a spindle which is inserted in an aperture in that end of the shaft, similar to the manner in which other gear-cutters are fitted.

To the opposite end of the spindle is attached an index-plate, which is to be retained in any one of its divisions by means of a catch, which can be arranged upon the apparatus in any manner which may seem the most convenient and effectual. If in the operation of cutting a gear a liability to spring be perceived, or if the catch be insufficient to hold the blank steadily in place, a set-screw, H, can be screwed down upon the bearing of the shaft, and there will be no danger of its moving.

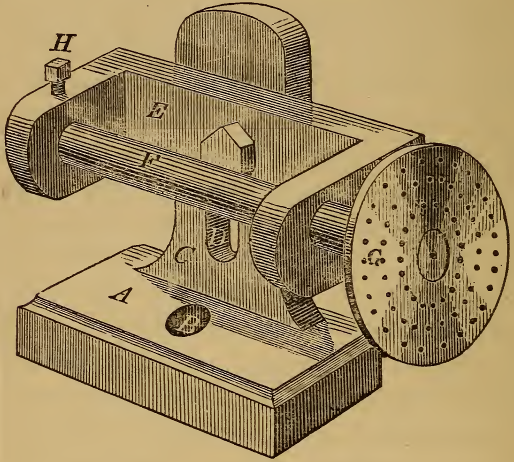

Fig. 30.

In the absence of an index-plate, a geared wheel having the necessary number of teeth, can be put upon the end of the shaft made for the index-plate, and it will answer every purpose.

It is necessary to run the blank gear to be cut over or above the cutter which is to form the teeth, as the hight of the lathe-spindle which carries the cutter is not often sufficient to admit of the blank being carried underneath it. There is another advantage in this arrangement—as the cutter revolves toward the front of the lathe it will have no tendency to pull off the blank, but have a contrary effect, which would not be the case if the blank passed under the cutter. The cuttings and dust produced by the cutter will fall down out of the way, and will not obstruct or impede its progress.

In setting this fixture to cut a gear, care must be taken to have the cutter-spindle stand in a line exactly at right angles to the axial line of the shaft which carries the blank, for if it be otherwise the groove cut will be wider than the cutter itself.

TO MAKE AN INDEX-PLATE.

THE mechanic often finds it necessary to lay out or make an index-plate, and excepting the method of spacing the blank or plate with a pair of dividers, he knows of no method of dividing it. If there be but a few spaces to be made, it may be done in this manner; but if there be any considerable number of spaces to make, let the plate be either large or small, much time and labor will be necessary to graduate the plate with a pair of dividers, so that it will approach to any tolerable degree of accuracy.

If the mechanic can have access to a correct index-plate already made he can copy it, and that, too, with but little preparatory labor. If this index-plate chance to be made upon the lathe pulley, as we have sometimes seen on lathes used by amateurs, the blank plate, already prepared for marking, may be put between the centers of this lathe, as is usual in ordinary turning, and then an iron block fitted into the tool-post of the lathe, so that it will stand parallel and near to the face of the blank plate to be marked. In the outer end of the block a hole must be drilled transversely, and in it a center-punch must be nicely fitted, so as to stand horizontally or at a right angle to the surface of the blank plate. The punch must be made capable of a longitudinal movement in the hole of the block, so that it may mark indentations on the blank plate. Fasten the index-plate of the lathe by any hole of the series to be copied, then with a light hammer strike the center-punch a sufficient blow to make an indentation in the blank, then turn the plate in the lathe one division, and make another indent on the blank, and so proceed until as many are marked as are wished, or until one entire circle is complete. Then move the blank with the marking punch inward the distance of another row of divisions, and mark another circle the same as the first. It is best to slightly mark, while it is in the turning-lathe, a series of concentric lines on the blank index, where the rows of divisions are to be made, and this will serve as guides enable the distance between the rows of holes to be made of equal distance from one row to another.

When all the indentations are made upon the blank plate, remove it from the lathe, detach it from the arbor on which it was turned, and drill a hole at each indentation. A copy of a geared-cutter index-plate, or of the plate of the index milling machine, may be copied or made much in the same manner.

Where no index can be obtained, another method may be employed. After the blank index has been turned up, and is ready for marking, a geared wheel, of the same number of teeth as the holes to be made in the plate, may be placed upon one end of the same mandrel that carries the blank plate, and if the teeth of this wheel be held like an index-plate, the divisions may be transferred to the blank in the manner described.

There is but one original method of graduation or spacing index-plates which the mechanic can employ with any profitable result when he has an index-plate to originate, and this method is simple, and can be employed by any one who feels so disposed. The first step is to bend a strip of steel into the form of a loop, and drill two holes through its ends, a little distance from each other, as shown in Fig. 31. When this is done harden and temper the ends where the holes are, so that a drill will not wear them or increase their size. Then take a long strip of sheet-metal which may be of brass or iron as is most convenient, or even a piece of narrow loop iron will do, and scribe a straight line longitudinally and centrally upon it. Place the loop at a right angle to the length of

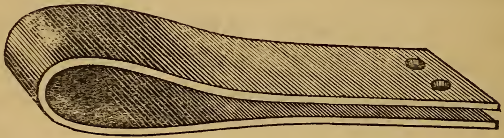

Fig. 31.

the strip, and drill one hole through it upon the scribed line, using the hole in the loop as a guide to drill through. Insert a steel pin in this hole and drill again through the other hole of the loop. Remove the pin from the first hole, and move the loop so that the pin can be inserted in the last drilled hole, and the other hole of the loop denotes where the next hole is to be drilled, and when this hole is drilled, advance the loop and drill again, and so proceed until as many holes are drilled as you wish the greatest number to be in your index-plate. When that is done, fasten the two ends of the strip together like a loop, and place it upon the periphery of a wooden wheel of the same diameter, and fix this wheel centrally upon the same arbor or spindle upon which the index-plate is attached, and arrange some kind of catch to hold this wheel where it is inserted in the holes of the drilled hoop, and mark one indentation with the center-punch, as described in the other operations, and repeat until as many are marked as are required.

It is not necessary to drill another strip for the lesser divisions, as the hoop can be cut open and a proper portion cut out, so as to leave the number of holes required; by turning down the wooden wheel to this size, it can be used as in the first instance. So proceed cutting the hoop and making it smaller, and turning down the wheel until the entire index-plate is marked with the number of spaces or divisions required.

Many of the divisions of an index-plate can be subdivided so as to answer all purposes of a smaller number of spaces. For instance, a circle having 240 spaces or holes may be made capable of the following divisions :—120, 80, 60, 48, 40, 30, 20, 15, 12, and 6, or a wheel of any of those numbers of teeth can be divided and cut from it. A circle of 144 divisions can be divided :—144, 72, 48, 36, 24, 18, 16, and 12. With 200 divisions, 100, 50, 40, 25, 20, 10, and 5 may be made. With 72 divisions, we can make 36, 24, 18, 12, 9, 8, and 6 ; and with 132 divisions, there may be made 66, 44, 33, 22, and 11. These five prime divisions :—240, 200, 144, 132, and 72, will be found sufficient for the ordinary work of a shop.

A MINIATURE PLANER.

THIS miniature tool, which resembles and is used very much as a common planer, but only on small work, is designed to be affixed to a common bench vise, and may be held in place by means of bolts as shown in the cut, or it may be otherwise fastened, as some other convenient method may suggest itself to the inventive mechanic. The jaws of the vise hold the work to be planed, and the necessary reciprocating motion is given to the cutting tool by means of a lever which is pivoted to a sliding bed, and then connected by means of a joint and arm to an extension of the casting upon which the bed is made to slide. To this sliding bed there is attached a transverse arm upon which the head-plate carrying the tool-post and cutting tool is affixed. This head has a horizontal movement on the arm, and is moved by means of a screw arranged like that of a slide-rest, and is actuated by a hand or feed wheel at one end, and this is turned by the operator, who can employ one hand to give the stroke to the tool, and, as each stroke is to be repeated, can move the feed-wheel, and consequently give the tool a side motion, sufficient to take a fresh cut upon the metal held in the vise jaws. The vertical movement given to the cutting tool is accomplished by

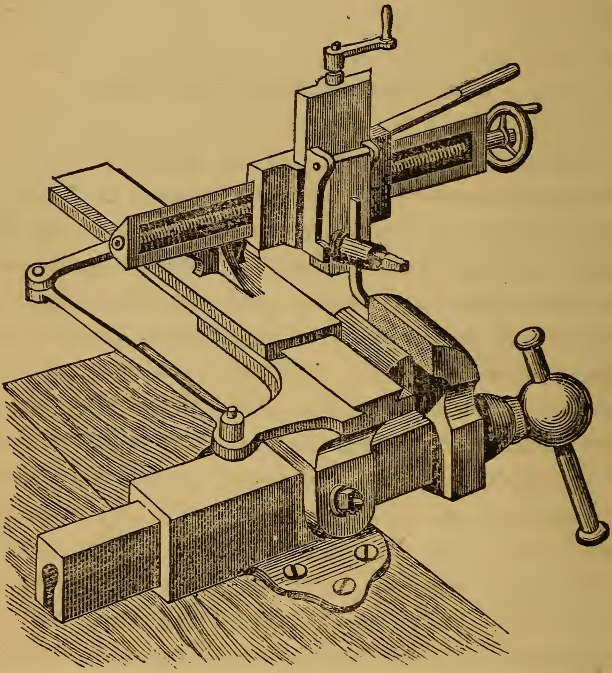

Fig. 32.

means of the handle seen at the top of the plate which carries the tool-post. The freedom given to the cutting tool in the back stroke to prevent its point being destroyed by abrasion is obtained by the plate which carries the tool-post oscillating on pivots at its upper end, the same as in the common iron-worker's planer, as used by the machinist.

Instead of the simple head, as shown in the engraving, the same arrangement that is used in the power planer to enable the tool to be set at any angle and fed by the screw that raises and lowers the cutting tool, may be used, and this arrangement will render this miniature tool as complete in its arrangement as the power planer.

The implement when placed upon the vise, as shown, is intended to supersede the use of the file, except for finishing, and at the same time accomplish more and in a better manner than the file and filer are capable of doing. For model and mathematical instrument makers it is especially valuable, as work can be accomplished by it which would be attended with a great deal of risk if it were clamped in the power planer, and perhaps the proportions of the work are so delicate as not to admit of thus holding it. For cutting ornamental rounds and hollows, grooves or corners, it can be employed where no other tool can be brought to bear on the work. It is in fact a miniature planer intended for delicate work, and accomplishes on a smaller scale the same kind of work and equally as perfect as its larger prototype.

A small size might be adapted for watchmakers and jewelers, while one of larger and stronger proportions can be adapted to the work of the model-maker and the small work of the machinist. At the present cost of files, not excepting its rapidity of reducing surfaces, this miniature machine would be an exceedingly profitable tool on ordinary vise-work.

WIRE-STRAIGHTENING.

As the wire to be used for ordinary purposes is sold in coils, it often requires to be straightened for use. The softer wires—such as copper and annealed brass and soft iron wire of small diameter—may be straightened by fixing one end in the vise or a pair of pliers. If the pieces of wire to be used are short, they may be straightened by rolling them between two pieces of board. The soft steel wire used for making needles is straightened by rolling or rubbing. It is cut up in lengths of four or five inches and arranged in cylindrical bundles, and inclosed with iron hoops, of about four inches in diameter, a hoop being placed at each end of the bundle. A bar of iron two or three feet long, is placed transversely upon the bundle, between the hoops, and rolled back and forth, the operation being performed upon an iron table. After a little rolling, the hoops are taken off, and the wires are found to be nicely straightened.

Hard-drawn and unannealed wires are too elastic to yield to these methods, and other modes must be resorted to in order to straighten them. We have seen mechanics stretch wire, as unwound from the coil, between two vises, and then by holding two pieces of wood, one in the hands and the other resting on their wrists, pass the wire under the one and over the other, and thus pass along the length of wire; but this is a very imperfect and unsatisfactory way of straightening wire. A better way is to improvise a fixture for the purpose by first scribing a straight line upon a piece of plank or upon the end of a work-bench, and driving about five good-sized nails or iron pins alternately upon opposite sides of this line, but with the ends of the pins leaned a little *away* from the line, or sloping in opposite directions, in order to hold the wire down to the board as it is drawn between them. Insert the wire in a zigzag or serpentine manner, by passing it outside of each pin alternately. It is necessary to be very particular, in pulling the wire through, not to allow it to lean sensibly against either of the last two pins, or it will assume some of its original tendency to coil.

The most convenient and effective wire-straightener is one made upon this principle, and so constructed as to revolve by applied power. The fixture is simple and easily made, and is shown in

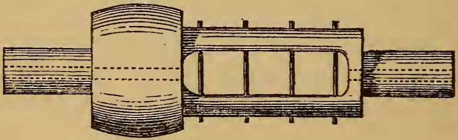

Fig. 33.

the annexed cut. It consists of a simple piece of cast-iron with four steel pins inserted. The entire length of the apparatus is about ten inches. A bearing is turned at each end, about an inch in diameter and two inches long. The pulley is a part of the casting, and is three inches in diameter and with a two-inch face. In the shell or open portion of the casting are inserted the four steel pins, which are placed a little to one side of a central longitudinal line, an inch apart, and are held by fitting tightly into the holes made to receive them. A hole, a little larger than the diameter of the wire required to be straightened, is drilled through the central axis of the bearings and pulley. The fixture may be mounted in an iron puppet-head or cheap wooden frame, as the taste or means of the mechanic may dictate. The belt used to revolve the apparatus ought to be about the same width as the breadth of the pulley, as in operation it requires a considerable amount of power to drive it. It is used by inserting a wire at the hole at one end of the bearing, and passing it under and over the steel pins and out through the end of the opposite bearing. Then set the machine running, and with a pair of pincers pull the wire through, and it will issue very straight and nice. While the wire is passing through it is necessary to lubricate it pretty well, in order to decrease friction and lessen the danger of cutting the different parts of the machine during its passage.

WIRE-CUTTING.

THE common cutting pliers are the most simple implements in use for cutting wires. The cutting edges of this tool are simply opposed wedges, the apex of each being presented to the work, and each cutter being capable of a movement in the arc of a circle by being pivoted together near the base of the cutting edges, the opposite ends extending some distance from the pivot and serving as handles or levers to produce the motion. When these cutting edges are compressed upon a wire inserted between them, they first indent the opposite sides of the wire, and when, by the force applied, the penetration is sufficient, the surface of the wedge-like form exert a lateral pressure against the material, which yields and is forced asunder at the moment the pressure exerted by the cutting edges exceeds the cohesive strength of the material not severed. If we examine the end of the wire thus cut we find that it exhibits two beveled surfaces meeting at a ridge which is somewhat torn and ragged. The softer the material or the sharper the cutting edges of the implement, the less of this ridge will be exhibited.

As the cutting edges of these pliers require to be quite keen, the angle of cutting tools as usually formed does not apply to them, and about half of this angle, or an angle of thirty degrees, is employed. As a consequence of this we often find tools of this character with their cutting edges notched and ragged from cutting hard wires, or by being used by unskillful or careless persons, who force the tempered edges of the cutters laterally against the wire, in which they are partially buried. When the edges of a pair of cutting pliers are destroyed they seldom admit of being reground or repaired, and the tool is thrown aside as useless. Attempts have been made to supersede this form of cutting pliers by instruments made with detachable blades, but have not been successful, as we still find the old cutting pliers holding a place in the market and a position on the bench of the mechanic. As an instrument for instantaneous use and in varied circumstances they are, perhaps, unequaled, and some of their advantages are that wire can be cut so that no burr is left to be taken off by filing or otherwise, and a cut can also be taken close to a shoulder or other object. Where wire-cutters are made with two edges passing each other like a pair of shears this cannot be done, yet such pliers have their appropriate place and use in the workshop economy.

When wire requires to be so cut that a square face is left, or, in other words, cut at a right angle to its length, other means must be applied than the cutting pliers. There are tools made especially for such operations, and in some shops we find they are often in use; but in places where such a tool is seldom wanted the hand pliers are resorted to, though their use is attended with some disadvantage, as they do not work so expeditiously, and do not leave the severed wire with a square-cut end. If there chance to be a pair of shears, such as are used in cutting sheet-metal, they can readily be adapted to cut wire by drilling several holes of different sizes near the pivot on which the blades are hung, but above the lower edge of the upper blade when it is closed upon the lower one. When this upper blade is raised and wire is inserted in one of these holes it is severed by the blade as it descends past the hole in which the wire is held. By making the several holes of different sizes as many sizes of wire can be inserted, and if the larger holes be made near the shear-joint less force will be required to sever the wire than if it were placed more distant. The use of the shear blades are in no way impaired by this arrangement for cutting sheet-metal.

We have seen an arrangement for wire-cutting attached to a lathe, and it consisted of a narrow blade of steel, made with appropriate cutting edges and bolted transversely across the face-plate of the lathe, and this blade revolved against a plate placed in front of it, and through this plate the wires to be cut were inserted. The distance of the cutting-blade from the face-plate to which it was attached determined the length of the piece of wire which was to be cut off.

A cheap and efficient wire-cutter may be made as shown in the cut, which consists of a steel forging fastened perpendicularly to the bench by an extension of the lower part of the plate, a nut holding it firmly in place. The upper part of the bar has a number of holes drilled to receive the wire to be cut, and at the extreme upper portion there is a hole to receive the bolt that forms the pivot upon which the cutting-blade is hung. It is almost needless to add that the part where the holes are made must be nicely tempered. It will be observed that the cutting-blade is made of a T shape, and hung upon the pivot bolt in such a manner that when the handle is lowered the cutting edge of the pivoted end severs the wire, which

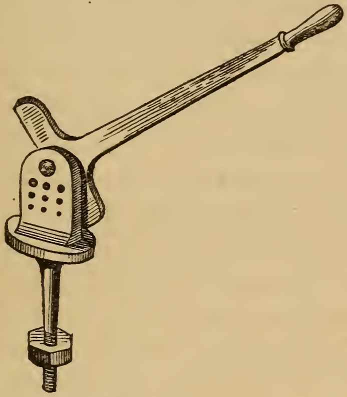

Fig. 34.

is thrust through any one of the holes in the plate. A gauge to determine the length of the wire can be fixed by means of a screw in the lower portion of the plate.

By making the cutter-blades of a T-form, if one blade should become broken or injured the opposite blade can be used, and no time will be lost at that particular moment in stopping to repair the injured blade.

COILING WIRE FOR RINGS, SPRINGS, ETC.

It often happens that the mechanic wishes to form rings of different sizes, made from wire or coiled springs which are to act by compression or extension. One method of doing this is to rotate an iron spindle in the lathe, and, fastening the wire at one end of this spindle and allow it to wind up upon it, and when the necessary length is thus wound it is cut into the number of coils with a chisel or by means of cutting blades placed in a foot or hand press.

The objections to this method of coiling wire are that short lengths or lengths equal to that of the spindle can only be thus wound, and, unless the coil be wound close, the spaces, as the wire is guided by the hands, will vary in distance. If two or even a greater number of wires be fastened at one end of the mandrel and wound together as a double or a many-threaded screw, and when thus wound and removed from contact with each other, coils of an even space between each turn can be readily produced. Another remedy for this variation is to hold an iron rod or a piece of stout wire between the coil and the wire as it is being wound, and this rod will, if the wire be wound close to it and it be held close to the previous coil, graduate the distance between them pretty accurately. An improvement upon the rod is to fasten it into a hook or loop so as to clasp the spindle, and the end or ends can be held by the operator with one hand while he guides the wire with the other. A tool similar in principle can be made of a bar of iron with a hole at one end in which the spindle loosely fits, the opposite end of the bar being fashioned into a handle. A hole of a size a little larger than the diameter of the wire is made at a point above the center, but at the rear of the spindle as the tool is placed upon it and held in the hand. The thickness of this tool determines the space between the coils, as, in being wound, the wire passes through the smaller hole, being fed on one side of the bar and winding or coiling upon the spindle at the opposite side of it. To use the tool in practice, place it upon the spindle, pass the wire through the small hole and fasten it to the spindle, which rotates and forms the coil.

An even coil can be made upon a lathe which is adapted for screw-cutting by setting it so that it would cut a screw of the same pitch as the coil is wanted. Place in the tool-post of the lathe, parallel with the axial line of the spindle, a piece of iron with a hole in one end large enough to admit the wire. Pass the wire through this hole and attach it to the spindle; set the lathe running, and the coil will be nicely formed, the feed regulating the distance or pitch. Wire from No. 1 to No. 15 can be coiled in this manner to good advantage. Wire larger than the size of No. 1 of the wire gauge can be coiled by means of two rolls which are geared together so as to revolve in opposite directions, the wire being wound upon one of the rolls, which has a spiral cut in its periphery of a depth equal to about one-third of the diameter of the wire. The groove, being of the same pitch as the coil is to be, serves as a guide to form the coil; and the opposite roll, which has a smooth face, serves to hold the wire in contact with, and confine it to, the spiral groove in the other roll in which it must wind or coil.

In these methods which have been mentioned the coils must of necessity be of the same length, or less, than the spindle upon which they are wound; but if it be desired to form coils of an indefinite length, other means and appliances must be employed. It has probably been observed with what facility sheets of iron, as used by the tinsmith and boiler-maker, are brought to the required curvature, and the apparatus employed consists of two cylindrical rolls which are connected by geared wheels so as to revolve in opposite directions. A third roller is placed opposite the two, and is free to be moved upon its axis by any body moving in contact with it, and this roll is made capable of adjustment. When used, the sheet of metal passes between the two geared rolls and strikes the edge of the third roll and is curled up, to enable it to pass over the same; and as this bending occurs in an equal degree at every point of the sheet of metal, it assumes a circular form, the diameter of which is dependent upon the position of the free roll. The principle employed is the application of three forces, as in a lever of the first order, or as in bending a rod across a fixed point. In coiling wire a machine can be constructed upon this same principle, and instead of rolls, as employed for plates, narrow wheels may be used, geared together so as to run in opposite directions, and grooves are made upon their periphery which guide the wire, and the third or loose wheel, made capable of adjustment, is placed in the rear of the fixed ones, its adjustment determining the diameter of the coil, and a flange at one side of this wheel pressing the wire in a lateral direction determines the pitch of the coil. In the sketch, *a* and *b* represent the two wheels geared

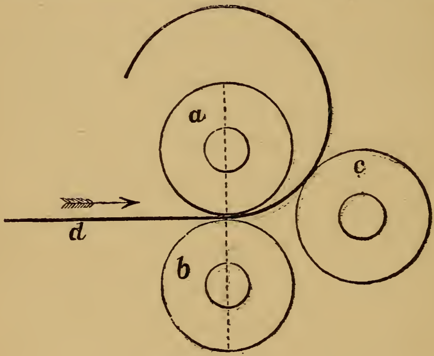

Fig. 35.

together, and *c* the loose wheel ; *d* is the wire as it is received in the direction of the arrow and issues in the curved form as shown. The principle has been explained sufficiently to enable the mechanic to comprehend it and construct a machine, for coiling wire if he should be called upon to do so.

RULE AND HINGE JOINTS.

OFTENTIMES the mechanic is called upon to make joints similar to those seen upon folding rules, and having little or no practical knowledge of the method of making this joint finds himself at fault, and a poor and ill-made piece of work is the result Examples of joints often required are seen upon pocket-rules, the drawing compass, bullet molds, and many other articles. The joint of the latter is perhaps the most simple one, as both portions are fac-similes of each other. The first step is to drill the hole for the rivet; this is done to both portions of the joint. Then make a "rose-head," or (as it is called in some shops) a "mill," the cutting-face of which is a very trifle convex and is made with the requisite cutting-teeth. The slight convex form of the tool produces a corresponding slight concave surface of work, and two such surfaces will, when riveted together, make a tight, close, and even working joint. If too much concavity be made, the outer edges may wear away and a looseness will be soon apparent.

The mill or tool which produces this cut must be centrally drilled at the cutting end for the reception of a guide-pin which is to be inserted in the hole, *a*, previously drilled (see Fig. 36), and ought to nicely fill it, and it must be long enough so that it can be inserted before the mill begins to cut; it will then form a steady guide while the corners of the teeth are removing the upper edge of the surface, *b*, preparatory to the reception of the round, *c*, of the other portion to be there inserted.

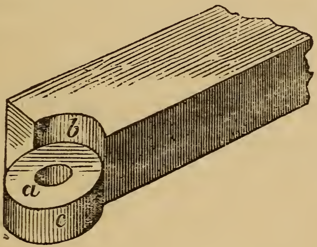

Fig. 36.

The forming of the round, *c*, is the most difficult part of the operation, and in large establishments where many of these joints are made, as in bullet-molds in the gun-factories, it is usually done at two cuts, each cut embracing one-half of the circle, and these cuts are made by means of the milling machine. But where a few such joints are required, or where the milling machine is not available, other means must be employed. One method is by filing. Turn a piece of steel of the exact size of the mill, which produces the cut at *b*, with a stem to fit the hole, *a*, then temper it so that it will not be reduced by the action of the file, and insert the stem in the hole and file the round, *c*, to the form of this guide, taking care to carry the file upon a line parallel with the body of the guide until the file just touches it for the necessary distance of the circle. When this is done remove the guide and rivet the two pieces together, thus forming the joint, the perfectness of which can be ascertained by opening and closing it a few times, and with a smooth file remove the portions which show where the surfaces come in too close contact.

There is a method of forming such joints by cutting the round upon the lathe by means of a small mill or cutter which has teeth upon the side as well as upon the circumference and made to revolve upon a spindle in the lathe as is shown in Fig. 37. After drilling the joint, place it upon a suitable pin attached in a rest, as shown in the engraving, and upon feeding it up, the abutting surface is cut where the two portions of the joint come in contact when opened to their greatest ex-

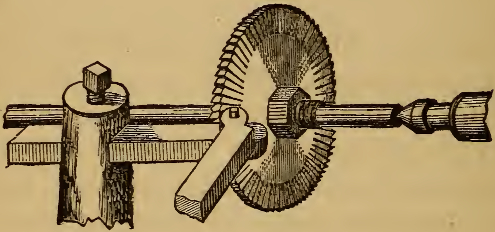

Fig. 37.

tent, and then, by turning the work slowly around toward the spindle on which the cutter revolves, a portion of the circle of the round, *c*, as shown in Fig. 36, is made ; but as only about one-half of this circle can be thus made the work must be removed from the pin and inverted, when the remaining portion of the circle is completed, the whole round and the abutting surfaces being produced at the two cuts. A little smoothing with a file will complete the operation.

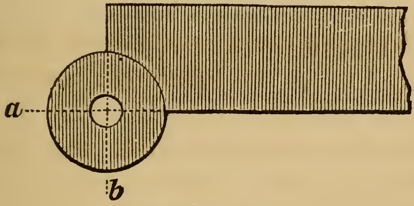

Fig. 38.

In laying out a joint a few instructions may be necessary, and these are given in Fig. 38. Make a circle of the exact size of the proposed joint, then through the center of this circle draw the line *b*, and at right angles to it, meeting the center of the circle, draw the line, *c* ; the angle, which is an an angle of 90°, forms the two abutting surfaces against which the two portions of the joint must open and close. The same rule of instructions may be applied to joints of almost any kind, and are adapted to those joints which are designed to open in an arc of one half of a circle, and there remain firm abutted against each other, which distance is sufficient for nearly all practical purposes.

With a little different manipulation a double joint is made, but it embraces the same principles as employed in a single joint. The hinges and butts used for doors and chest-covers are made after the principle mentioned, but instead of a single joint, are formed with two, three, or more joints upon the same piece of metal, and when connected together as we see them in use they form a much stronger connection than if they were made singly.

TO MAKE A "KNURL."

THE "knurl," beading, or milling tool, as it is variously named, is often called into requisition by the mechanic for the purpose of ornamenting the beads or swells of the work he is engaged upon. These knurls are generally purchased at some of the hardware stores, and are used by inserting them in the end of an iron shank, where they are free to be rotated by any moving body being held in contact with them, and if they be held rigidly enough they will make upon it a figure the reverse form of that upon their periphery. Knurls are generally made with about three forms of face—straight, hollow, and rounding—and these forms are cut with straight or beveled teeth, or designs of different degrees of coarseness.

If at any time the mechanic has one of these forms, a hollow for instance, which is suitable for beading a swell, and he wishes to produce the opposite of this, or a round-faced knurl, he can turn up a steel blank of the required form and hold the hollow knurl against it until the form of its teeth is fully impressed in the surface of the blank. This then can be hardened and tempered ready to be used for the production of its reverse. In this way a sharp knurl may be used to produce a great number of others, or when they become dull by usage they can be restored by it to their original excellence.

But as it is often desired by the mechanic to make a knurl the teeth of which are required to be coarser or finer than any he possesses or can purchase, he can readily do it by first turning a blank to the form required, and then cutting a small screw with the same pitch of thread that the knurl is wanted to be, then cut grooves across it the same as a hob is made for cutting screw-chasers. Temper this screw and fit it to revolve in the lathe. Attach the blank knurl to a shank, the same as it is used in actual work, and hold it in a vertical position so that it will revolve by the action of the screw as it is held against it. The rotation of the screw will cause the blank to revolve, and a serrated surface will be formed upon it at the same time. While doing this it will be necessary to support the shank that carries the blank upon a T-rest.

If the blank knurl be made with a hollow face, the screw to cut it must of a necessity be of a size proportionate to the hollow; but if the blank be made with a flat or rounding form then it must be moved in such a manner that the screw will cut every portion of the face evenly and alike, and this can be done by moving the handle that carries the shank, as it lays upon the rest up and down, and by so doing presenting the blank correspondingly to the cutting surface of the screw.

If ornamental knurls are wanted, the services of the die-sinker must be brought into requisition, who will produce a reverse of the ornament needed, and then reverses of this can be made in the manner mentioned, or they may be so made that they can be used upon the work without the necessity of using them as patterns to form working tools.

HOW TO MAKE METAL TUBES.

Tubes of metal are used for a variety of purposes, and in all large cities and towns are easily obtained of almost any size; but there are times when the mechanic finds it an impossibility to obtain what he wants of this kind of material, and he must manufacture a tube for himself. If the tube is required to be of two inches diameter inside, a narrow slip of metal is cut off and bent close about a mandrel or spindle of that size, until the ends just meet; this slip when straightened out gives the breadth of the piece which is to form the tube. Cut a piece of this breadth from the metal, taking care that the edges are exactly straight and the breadth uniform; brighten the surface for about a quarter of an inch by filing it at the opposite edges on the same side. Then place the piece of metal upon a spindle and with a mallet bend it round it until the edges come in contact and lie very close and even together, the brightened parts coming together on the inside and presenting a clean surface for the reception of the solder.

If the tube be exposed to the fire for soldering in this state, especially if the metal be thin, the heat would cause the suture to open, and it would be imposible to solder it; to prevent this, place loops of small wire, at an interval of about an inch or so apart, around the entire length of the tube, and twist them so as to bring the edge of the metal in close contact.

The tube so prepared is ready for soldering, and borax and spelter must be used for that purpose. The borax being previously burned or made to swell into a friable mass by exposure to heat upon an iron plate, is triturated with water to the consistency of cream, in which state it is rubbed along the inside of the tube upon the seam; upon the borax a portion of spelter solder must be laid. Place the tube over a good charcoal fire with the suture downward, until it becomes slightly red-hot; at a cherry-red heat the borax will melt, and presently the solder will fuse, and as this fusion proceeds draw the tube along so as to expose every part of the line or joint to the action of the heat.

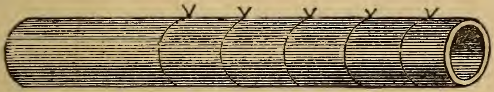
Fig. 39.

When finished remove the wires, and put it in a pickle of sulphuric acid diluted with water; after half an hour remove it, wash and scour it clean, and it is ready to be wrought as may be desired.

PRODUCTION OF IRREGULAR FORMS.

MANY kinds of irregular forms are produced in the machinist's lathe by means of peculiar-shaped turning tools, as, for instance, the swells, beads, and bosses upon the ornamental portions of machinery. These simple ornamental profiles consist of what is technically known as rounds and hollows, sometimes placed separately and at other times in juxtaposition or separated by a slight indentation. The manner of making these forms is to form the cutting face of the turning tool with a shape the reverse of that intended to be made, and this shape is generally produced by means of the file; but the process is slow and tedious, especially where a complexity of form is wanted; and where a duplicate is wished it is a somewhat difficult operation to thus produce it. If the mechanic was conversant with some easy and simple means of producing these peculiar-shaped tools, they would, no doubt, be oftener used, and add much to the beauty of tools and machinery. It may be supposed that every machinist has among his tools a spindle for carrying the saws used for slotting screw-heads and for other similar purposes. If the workman make two or three different-shaped cutters similar to these saws, and of the precise shape he wishes to produce upon the work, and then place them upon the spindle and then place them upon the spindle and rotate it between the lathe-centers, and if the end of a blank tool be fed up to the cutters, they will cut a reverse of its form in the blank, and this can be properly finished by hand to constitute a turning tool and tempered for use. As many tools as may be desired can be thus produced, and when they are worn out, the spindle and circular cutters can be again brought into requisition, and duplicates of the tool are cheaply and readily produced.

One example of this reproduction of given forms is seen in that kind of adjustable or monkey wrench in which the jaw is moved back and forth upon the bar by means of a nut which incloses the bar, a thread being cut upon the interior of the nut and upon the corners of the bar. It is necessary that these nuts where they are attached to the jaw should be of one size and form, and they are produced in the lathe by a single tool as stated.

In this method of forming these tools the end lines of the cutting surface are of concave form, corresponding to the diameter of the cutter which formed them. If a plane instead of concave surface of tool is wanted, a different method must be employed in its production, and although it may seem somewhat difficult to do in the lathe it is, nevertheless, quite easy. Attach by means of bolts or screws to one side of the lathe carriage, and midway between its front and rear ends, a piece of iron which has a recess made transversely to the length of the carriage, and of the size of the body of the tool, and this recessed side must be placed next to the side of the carriage; it will then form a mortise in which the tool will fit, and a screw upon its outer side may be made to confine it in place. The necessary angle of inclination to the rear at which the tool must be placed, or at which this mortise must be made, is about 60°. Confine the blank tool thus, place the spindle and cutters in place, then run the blank under the cutters from the rear, using the necessary precaution of careful cutting and slow feed, and a nice straight-faced tool shaped the reverse of the cutter will be the result. The reason why the tool to be cut must be inclined to the rear and the cut taken from the rear side is obvious, for if it were inclined to the front the action of the cutters would drag the blank toward them, and the result would be, perhaps, a breakage of the cutter-teeth and an unsatisfactory cut; but when the blank is inclined toward the rear, the action is to force it back as well as cut it, and no danger of breakage need be apprehended, and a smooth cut, which will scarcely need touching in order to finish it, will be the result. This can then be smoothed with files of fine cut teeth, and polished if necessary, tempered and used as a common end-cut tool.

CLAMPED DIES.

Another means, and a very cheap and expeditious one, of producing irregular forms is by means of clamped dies, which operate the same in principle as the lathe tool; but instead of the one cutting point, as in the example of the lathe tool, it has two cutting edges—a front and a rear one—as the dies close together. Another additional advantage over the lathe tool is that the irregular surface of the work produced has a bearing upon nearly its entire circumference while it is being produced.

This principle of clamped dies may be applied in cases where the turning tool could not be well brought to bear. The turning of the wrists of small cranks is an example, as in the cranks of sewing machines, where the pitman is attached. To produce or turn a smooth surface upon that spot by means of the turning tool would involve the necessity of either bending the ends of the shaft so that this part would be exactly in the line of rotation, and when finished the ends thus bent must be straightened out, or at each end of the shaft, arms must be attached, involving the same principle as in the previous plan, but by means of clamped dies the wrist for the pitman may be turned very expeditiously, and upon the same centers as those on which the shaft was turned. Let the mechanic take a common die-stock, in which the dies are forced together by means of a set screw at one side of the stock, or one in which the handle answers the same purpose. Let him fit to this stock two dies in the same manner as the dies for cutting screws are fitted, and let them be of the shape of the screw die, supposing the threads were filled up or the die was made with no thread. It will be obvious that by clamping these dies together a shaving of the rod or metal upon which they are clamped, will be removed, and they will so continue to act as long as the forcing together of the dies is continued or until the diameter of the work is reduced to the same size as the circle of the die which clasps it. We may regard the die-stock and the screw-dies as examples of clamped dies, in which the metal is removed in precisely the same manner; but by peculiar formation of the thread the die is advanced in a longitudinal direction in a proportion to the pitch of the thread.

It is evident that irregular forms may be produced by this means as readily as plane ones, by means of irregular-shaped dies, and these dies are cut or formed by means of tools which cut in the same manner as reamers, but of the same form to be produced. These tools are turned or produced by tools in the lathe as may be most convenient, and when thus formed ought to be nicely polished; then by means of the file, or the better process of cutting by the milling machine or planer, cut longitudinal grooves in such a way that they will be formed like the teeth of a reamer and act in like manner. When these teeth are thus nicely made the tool must be tempered. If the blank-dies are now made to inclose this tool and tightened upon it, oil being supplied in the meantime, it will as it revolves form its counterpart in the blanks. When it has cut of a sufficient depth the dies are removed, the edges or sides formed at an angle to produce cutting edges, and tempered for use. When these edges are dulled they are restored by grinding the angle which constitutes the cutting edge.

Examples of the use of these tools are seen in trunk, cabinet, and door keys, at that irregular-formed portion between the bit and the bow. In the process the key is held by the bit by slipping it into a recess made to receive it, so that it will properly revolve, and the dies applied. If these dies were placed in the die-stock, as in the illustration we first gave, it would require some expenditure of time to insert and move them; but if these dies be placed in a pair of clamps or tongs, as they might be called, they can then quickly and readily be applied.

This process has been used in the production of screws, of swells, or ornamental beads upon rods, the work being held in a pair of revolving clamps which rotated in the lathe. To enable the work to conform to the dies the clamps must be susceptible of some lateral play or vibration, and this is generally done by making them of some length, perhaps a foot or two. In the making of screws the clamps are to be attached to the end on which the screw is cut, and the body of the screw and head are formed at one and the same time. This end by which they are held may be quite short, and can be cut off when the finishing of the screw is to be done.

To what extent this principle is capable of being extended we do not know, as we have no recollection of seeing it applied to articles above an inch in diameter; but as movable dies are successfully used in cutting very large screws, we presume no difficulty would be found in extending these same clamped dies. The smallest articles so produced of which we have cognizance were a lot of bearings for sewing machine shuttles, the one in which the end of the thread-bobbin revolves.

DUPLICATING IRREGULAR FORMS.

With the exception of the taper, no means are provided upon the engine lathe to turn automatically any other form than that of a cylinder ; yet irregular forms are often needed to be produced, and with *fac-simile* lines. The usual method of doing this is to "rough out" the form by means of the diamond-point tool, following the required shape by moving the tool "in or out" by means of the handle attached to the screw, which serves to move the handle to or from the work, then go over it in the same manner with a round-nosed tool, and finally finish up with hand tools, or use a file upon it as it revolves, and then, if so desired, obliterate the file marks by means of grinding with emery.

We see in machine-work that the handles inserted in wheels and in cranks for the purpose of rotating them, and often other parts or portions of mechanical appliances, are formed with easy curves ; yet with tools which move only in straight lines, or transversely with these lines, as in the lathe-feed, with no other guide but that of the human hand, the production or reproduction of these curves is not so easy a matter. But any engine lathe, or lathe which has an automatic feed, can be easily arranged so as to produce a curve and its duplicate almost *ad infinitum.* It is done in this way :—Remove the screw by means of which the cross or transverse feed is accomplished, and as the tool-block or tool-post is carried or held up to the work by this screw, it is evident that the point of the tool will then recede by the force of the work as it rotates ; but to remedy this we will attach an arm to the rear end of the saddle, as that part of the rest is called which rides upon the way of the lathe-shear and attach to this arm a small pulley grooved so that a cord will run over it, fasten the cord to the upper portion of the tool carriage which moves transversely upon this saddle, and when the cord is passed over the arm and a weight attached it will hold the tool up to the work so that the resistance will not cause a backward motion. If we attach a plate of iron or steel of the same shape we wish to turn to the lathe-shear opposite to the work to be turned, so that it will remain quite firm, and fix a small piece of steel placed vertically to the carriage, so that the edge of this vertical piece will travel against the pattern as the carriage is fed along, it is obvious that, under the action of the weight applied at the rear, the motion of the tool "in and out" will correspond exactly to the form of the pattern attached to the shear, and when the tool is set at a certain distance from the axial line of the work, the exact reproduction of that form will be the result as often as it is permitted to traverse the different pieces upon which it is brought to act. By setting the tool nearer the work a smaller form, or by removing it a little, a larger one, but of the same length and profile, will be the result. Besides the advantage of exact reproduction, the operation is done automatically, and requires no other care from the workman than that required in turning a cylinder; and if a finishing tool be applied, a finished surface can be produced on the curve as well as upon the cylinder. The taper can be produced in this way, or a cylinder, formed with tapers, cones, or swells upon its surface at intervals, can be turned as easily and as readily as the cylinder.

TO TURN A TAPER.

ENGINE lathes of the present day are made with the tail-stock in two parts—a base or bottom portion which is fitted to the ways of the lathe-shear, and an upper part attached to this base and carrying the spindle. This upper portion is capable of a transverse motion upon the lower one by means of screws, and it may be retained at any point, either in an axial line with the spindle or a few degrees removed from this line.

If the mechanic wishes to turn a taper he moves the top portion of the tail-stock to the front or rear, as may be desired, and as the cutting tool always moves in a line parallel with the axial line of the "live" spindle which carries one end of the work to be turned, and the "dead" spindle supporting the other end, being thus moved away from this axial line, it will be evident that the shaft or rod to be turned will be reduced to the form of a taper in the same proportion that the dead spindle is moved away from this axial line. This is the means as generally employed by mechanics to produce taper forms.

Iron turning lathes have been made which indicate the amount of this taper, but the lathe so commonly met with does not do this, and some means must be resorted to to ascertain if the lathe be "set," as it is called, so as to produce the required form of taper. We have seen mechanics guess at it, setting the tail-stock spindle a little distance from the line to turn a cylinder and taking a light cutting off the work, and then moving it again until it is at the required place. A very correct method of setting a lathe very near the exact point at the first trial is to insert the work—a shaft, for instance—and turn a small portion of the small end or tip of the taper of the required size, or leave it a little larger, to allow of a finish cut being taken. Then reverse it and turn the large or base end for a little distance the size or a little larger than it is to be; then reversing the shaft, leaving the tool in its place, the small end being opposite the tool, loosen the screws that confine the tail-stock to the shear, and this will free the part that carries the spindle; then, by means of the screws at the side, move the dead spindle until the turned portion on the small end touches the tool, and then confine the spindle and tail-stock in place. It will be obvious that the cutting tool must follow in a direct line from the small portion of the shaft to the larger or base end. If it be not exactly the taper required and is left a little large, the tail-stock can be moved a little to meet the required form and a finish cut can be taken which will in all probability be the required form.

If it should so happen that the lathe in use is not made with the spindle to be "set over," but if it has the usual rest and feed-carriage it can be arranged to turn a taper by inserting an iron-wedge under either front or rear end of this carriage, according as the taper is to be produced or as convenience will admit. If the base of the wedge be placed toward the head-stock and so that the front end of the carriage will travel upon it, it will raise the point of the turning-tool as it feeds along and a decreasing size will be made upon the shaft; but if the wedge be similarly placed, but made to engage the carriage at the rear end, the opposite effect will take place. This same arrangement can be used upon the lathe with the movable tail-stock, if it be desired not to move it, to produce this effect. If it be desired to turn a cylinder a certain distance and then produce a taper, the lathe may remain so as to turn the cylinder, and at the proper point the wedge may be inserted and the taper produced without change of lathe or change of turning-tool.

In what is known as the gibbbed lathe this cannot be well done, and is best accomplished in the lathe in which the tool carriage is held in place to the shear by means of a weight.

By an application of wedges of irregular form the same or contrary forms can be given to the work in the lathe, according as these wedges are inserted under the front or rear end of the carriage. The form of the wedge must be made to assume these irregular forms gradually, as abrupt forms or curves cannot be very well executed by the turning-tool.

PRODUCTION OF CYLINDRICAL SURFACES.

THE machinist's lathe, with its automatic feed, is the means generally employed for the production of cylindrical surfaces; but although this may seem a very easy means of producing cylinders of exactly the same diameter or of unvarying diameters, it is nevertheless quite difficult to produce two cylinders of any great length, of exactly the same diameter or of equal diameter throughout their entire length. The reason of this is obvious; upon the commencement of the work the cutting point of the turning tool is quite acute, but soon becomes somewhat obtuse after cutting a little distance, and of course the work is left of a greater diameter as it progresses; then again the ways of the lathe in lapse of time become worn or reduced in the places where the carriage travels most frequently, as dust and debris will get between the bearing surfaces of the lathe and carriage, and a reduction of these surfaces will result. The means usually employed for the production of cylinders of equal and like diameter, is first to turn it with the point tool as near as possible and then to finish it to the size with a fine cut file, applying the file as the work rotates in the lathe, and ascertaining the diameter by repeated trials with the callipers. If this cylinder is to fit into a corresponding aperture, it is sometimes filed until it nearly enters, and is then ground to fit by means of oil and emery or some abrasive substance.

It has often been a desideratum with mechanics to have some adjustable tool that might be applied to a cylindrical surface, and it would produce other cylindrical surfaces of an unvarying diameter, but as yet no such tool has found its way into the economy of the workshops. The tool usually employed to obtain cylinders of like diameters is shown in Fig. 40. It consists of a short cylinder of steel, through which is drilled a hole of exactly the same diameter as that to be produced. Upon the end to be presented to the work are radical teeth which, when presented for operation, act as so many cutting points to remove the superfluous material. This tool can be rotated in the lathe by being held in a chuck, or the work can be rotated and the tool held in a clamp and the work given to its action; it is passed longitudinally over it. If this tool be of any considerable length the work may bind at its rear portion, and where such is the case or if it be apprehended, that portion of the tool may be bored out a trifle larger than the front portion.

In a shop where twist drills are used and fixed measurements are a standard guide to the workmen, these tools may be used and the twist-drills are a ready means for their production, but as their cost is quite considerable their use will be limited. They have been profitably employed in the manufacture of short bolts and screws, and many kinds of work of which short cylinders are a component part. If two cylinders be desired of different diameters, but attached to each other and concentric with their centres, two of these tools, similar to the one in the cut, may be used at the same time, the aperture of each corresponding to the diameter desired. In use the larger tool must be placed over the smaller one and confined to it by means of a set screw. Or if three sizes of cylinder be wished, three of these tools can be simultaneously employed. The length of each portion of cylinder can be obtained by regulating the distance between the ends of the tools before they are brought to act upon the work.

Some attempts have been made to adopt an adjustable tool with detachable cutters to produce cylinders, but such a tool has not been very satisfactory in its performance. The tool represented in the cut has sometimes been made with a num-

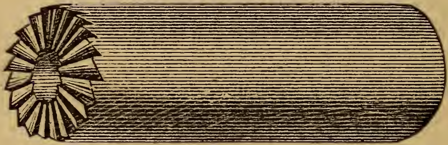

Fig. 40.

ber of longitudinal cuts made with a saw, extending from the cutting end some distance toward the body of the tool, and a ring encompassing the tool and provided with set screws, which by their action as they were turned found a bearing against the cleft portions of the tool and so constructed the aperture. This has not been very satisfactory in practice, and the solid-made tool has been the only one that has been considered the best and most reliable ; and when worn so that it gave a larger diameter, it was thrown aside and a new one substituted.

GRINDING CYLINDRICAL SURFACES.

The turning of long and slender rods in the lathe, so as to have them of a true cylindrical form, is quite difficult even when a back-rest is used; irregularities which are unobservable by the eye are easily detected by passing the rod between the fingers. Even short and thick rods, that are too rigid to spring under the action of the turning tool, are found to have slight irregularities, which may be accounted for by imperfections of the lathe or by the wearing of the tool, or from hard or soft places in the metal. It will be observed, then, that to produce a perfect cylindrical surface in the lathe is a matter of some difficulty, and the only method seems to be to turn the work as true as possible, and then complete it by grinding with some abrasive substance, as powdered emery, moistened with water or oil, which is the material generally employed.

The application of emery as an abrasive means for producing cylindrical surfaces is quite simple, as it is evident that the cylinder must be confined between surfaces the counterpart of those to be produced, and then well supplied with the abrad ing material; it is quickly revolved and operated upon until the requisite surface is produced. If a block of metal, as iron, steel, or brass, be bored with a hole of the size to which the rod is to be reduced, and one end of the rod made to enter this hole, both rod and aperture being well supplied with oil and emery, it is evident that by moving the block in which the rod is inserted over the length of the work, it will be reduced so that it will correspond to the diameter of the hole. A block of lead or tin may be cast around the rod and supplied with emery and oil and operated as mentioned. This perhaps is the readiest way of forming a block, as it is easier to melt and recast the soft metal than it is to prepare and accurately drill the iron or steel block. The latter is useless unless of the proper size, but the former can be often remelted and used as at first.

For the use of the amateur an abjustable tool which may be recommended, consists of two cast-iron or brass shells, cylindrical in form, and of a length sufficient to keep them steady upon the work. These shells have ears upon each side, and screws pass through these ears and confine the two parts or halves together. Two middle ears may be made with set screws to prevent the shells being closed beyond a certain point. To each of these shells handles are attached, so as to enable the operator to hold the tool and also to enable him to traverse it over the rod to be ground. The interior circles of the shells are made so that when the tool is placed around the rod it is much larger than its circumference, and this space is filled with molten tin, lead or babbitt-metal. If a difficulty should present of the soft metal not retaining its place, several small holes may be drilled a little distance in the shells, and the metal filling these holes when cast will form a sufficient hold to retain it. By slacking the set screws and tightening the binding screws, the size may be varied, to suit small variations of diameter in rods.

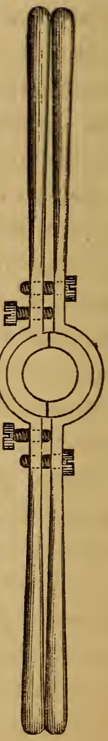
Fig. 41.

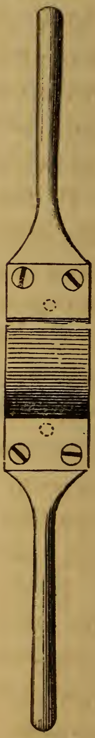
Fig. 42.

A side view of this tool is given in Fig. 41, and a top view in Fig. 42. The set screws and binding screws enable the circular aperture to be kept rigidly of a constant diameter, except as it may be enlarged by the material used in the grinding process.

For the purpose of casting the lead or tin within the shells, the set screws are withdrawn and the binding screws are slackened so as to leave an opening of about a quarter of an inch between the flat faces of the shells. They are then placed edgewise upon a block or some level support, and a short cylinder or core of the same diameter as the cylinder to be ground is placed centrally in the aperture of the shells, and two slips of wood are placed so that they form a continuation of the circle where this circle is broken by the separation, and then the parts are firmly pinched together by the binding screws, the melted metal poured in, so that it fills the cavity and encloses the core. The slips of wood serve to keep the shells at the required distance apart, and also serve to retain the metal, which otherwise would flow out at those places. It is almost unnecessary to repeat that the aperture of the shells should be much larger than the work to be ground, and the slips of wood taken out when the tool is to be used.

To keep the core centrally in the aperture of the shells, while the metal is being poured, it may have a portion of its length inserted in a hole in the block or board on which it is placed. If it be desired to cast the metal round the work itself, it may be so fixed and the metal poured. To prevent the flowing out and waste of the metal, all such points as would be likely to afford such escape are luted with clay, or even common putty such as is used by glaziers to fasten in windows may be used.

In using a tool of this character after the rod to be ground is put in rapid rotation, the tool is grasped with the hands and transversed backward and forward over the rod, and as the parts presented to its action are reduced the set screws are loosened and the binding screws are correspondingly tightened in order to decrease the circle and enable it to clasp the work with the requisite pressure. Adjust the tool and pass it over the rod until it continues to slide smoothly and with uniform resistance from one end to the other; oil and emery are to be applied during the entire operation.

It is advisable to make the grinding surface as near a counterpart of the cylinder as possible, and if a very perfect surface be desired, it would be well to reduce the inequalities with the application of one set of soft-metal castings, and then remove them and cast a fresh set with which to complete the operation.

Another application of this method is to fix the grinding tool in the tool-post of the lathe, and let it traverse the work from end to end, as it is rotated, keeping it supplied with oil and emery and advancing it to the work as it is reduced. In this case it is not necessary to encircle the cylinder or rod with a metal block, as an encircling of one-third or one-half the circumference is sufficient.

In some kinds of machinery it is necessary to accurately grind large rolls so that they may be perfectly true, and after these rolls are turned in the lathe as true as possible, they are mounted on their own bearings in a frame similar to that in which they are to be employed, and made capable of a slow rotation. A wooden cylinder supplied with a coating of emery is revolved with great velocity just in contact with the roll, which as it slowly turns is reduced by the quick-running emery-wheel. The roll must revolve in a direction opposite to that of the emery-wheel.

The same application may be made in the lathe, by slowly revolving the work and fixing the emery-wheel in the tool-post of the lathe and letting it traverse the work, the necessary speed being communicated to the grinding-wheel from any convenient pulley.

Musket and rifle barrels were formerly reduced to a proper size and cylindrical form by the abrasion of a quick-revolving grindstone. An iron rod was inserted in the bore of the barrel, which was then held in a suitable recess in a swinging frame, and upon being brought in contact with the revolving stone the barrel was slowly turned by means of a crank attached to the rod upon which it was held until it was properly reduced.

GRINDING INTERNAL CYLINDRICAL SURFACES.

INTERNAL cylindrical surfaces, such as the bearings for spindles, are ground with cylindrical rods and fine emery which may be of wood, lead, tin, brass, or iron. Two kinds of these grinding-rods are employed: solid cylinders of the required diameter, and using a succession of such cylinders as the aperture is enlarged; or the rods may be made with a small power of expansion to avoid the necessity of several solid ones.

The simplest form of grinding-rod is to select a bar of iron, and make a cast lead or other soft metal of the required size upon it. If it be the aperture of a pulley that is to be ground, the iron rod may be inserted in the hole and luted at the bottom to prevent the escape of the metal, and then the melted metal is poured in until the aperture around the rod is fully charged. The rod is then withdrawn, the lead covered with oil and emery and inserted in the hole. The pulley is either rotated or it may be held fast and the rod rotated. To prevent rings forming by unequal abrasion, it is necessary to give a longitudinal motion to either the rod or the object being ground, and as the metal upon which the abrasive material is applied is of the same length as the hole being ground, it is limited in its longitudinal motion. This difficulty can be obviated by casting the lead upon the rod in any convenient mold which is larger and longer than the aperture to be ground, and then turning it in a lathe to the required dimensions. When such a rod is passed through a hole it will equalize it, and there is no danger of forming rings. To facilitate the entering of the casting, it may be made slightly tapering at one end. Where there are two holes or bearings to be ground, which are parallel to each other, the same rod is made to serve for each, and at the same time serve for a guide to insure the holes being ground parallel to each other. In grinding two holes parallel to each other, but of unequal diameter, two castings of the same unequal diameter are made upon the rod and turned to the required size, one to fit the larger and the other to fit the smaller hole. Both holes being ground at the same time insures their parallelism.

Short cylindrical holes such as in ring-gauges, circular cutters, case-hardened plates with holes, etc., may be accurately ground by revolving the work in a lathe, and applying a grinding tool made of soft iron, copper, or lead, which is of the required size, and charged with oil and emery. A cheap grinder may be made by making a wooden rod of the size of the hole, then split one end of it and insert a wedge, which may be advanced as the hole is enlarged. If preferable the rod may be rotated, and the work held in the hands or fixed in a slide-rest. For holes in small work a steel rod may be bent so as to form a circle at its center, and the two ends brought parallel near each other ; the cylinder of lead may be cast upon these ends, and then sawn asunder longitudinally and then made to extend apart by springing the central portion ; the elasticity of the metal being sufficient to produce the force to accomplish the abrasion, or if this should prove insufficient, the wedge may be employed as just stated.

If it be desired to make a cylinder grinding-rod that will answer for several-sized holes, it may be made in two halves to allow for expansion, each half being semi-circular, and one being fitted with a steady-pin at each end, which is received in recesses made in the opposite half. A series of binding screws, dependent upon the length of the bar, but with their heads sunk below the surface, are inserted in either bar and received in tapped holes in the other. By loosening the screws upon either side the two bars may be retained at any convenient distance, dependent upon the length of the screws. To cast the lead upon the bars

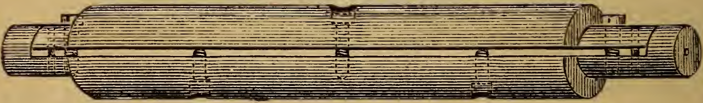

Fig. 43.

they are separated, and a thin slip of wood inserted between them so that the lead when cast will be in two semi-circular portions. The wood may be removed or retained as may be desired.

The molds for casting these soft-metal cylinders may be a block of wood with a hole bored in it, or a sheet of stout paper may be wound upon a cylinder of the requisite size and confined with a cord. The cylinder may then be removed, and the bar inserted preparatory to pouring the soft metal. In melting lead or soft metal for the purposes named, care should be taken that it be not too hot, or the casting may contain air-holes and present a honey-combed appearance. If lead be used a piece of paper may be inserted in it when it is melted, and when at a temperature to just scorch the paper it may then be poured into the mold.

FITTING EXTERNAL AND INTERNAL CYLINDERS BY GRINDING.

It is frequently necessary to fit external and internal cylinders by grinding, and often these surfaces are hardened, as steel when tempered, or iron when case-hardened, and by these processes of hardening or tempering the cylinders have warped or sprung from their original shape and form. If the cylinders are not much distorted by the process they have been submitted to, they are easily fitted by the internal cylinder being ground so that it will enter the external one for a little distance, and then oil and fine emery being plentifully supplied to both the external and internal surfaces; the cylinder is then gradually worked in, using at first a circular motion only until it has entered sufficient to have a firm and steady hold, so that it will guide itself; then using the external cylinder the same as a solid grinding-rod, work it back and forth with a screwing motion until it is fairly entered and properly fitted.

It should be borne in mind that during the whole operation of grinding, the surfaces should be plentifully supplied with oil and emery, for should they by any chance become dry, the friction will cause them to heat, and this may become so great that minute fragments of metal will be torn off and become so ground into the surfaces of both cylinders that it will require some effort to separate them, and oftentimes some force must be used, to the detriment of the work. This is especially liable in untempered or work not hardened, as in fitting soft iron cylinders or fitting iron and brass cylinders together; but in hardened work the risk of its thus sticking together by the torn fragments is not so great, and the only danger will be that resulting from the heat and expansion during the process.

In cylinders of soft metal there is another evil resulting from grinding, and that is the embedding of particles of the emery in the metal, which if the surfaces be journals or parts which are to work in contact, the particles so embedded will continue to abrade and eventually result in great injury, if not the complete destruction of those parts.

When cylinders are being ground together the operation should be kept up until one will slide within the other with a uniform resistance, and then remove them and carefully and thoroughly clean them from all traces of the abrading material; then coat them with clean and pure oil, and work them together for some time, which will serve to remove the traces of the emery, and will also serve to put a fine finish or polish on the surfaces so operated upon.

The evil resulting from particles of emery becoming embedded in brass work is remedied by using powdered pumice-stone and water, which from its softness is more easily removed from the metal. But no matter what material may be used for such operation, the greatest care should be used to carefully remove all traces of the abrading powder from surfaces which will come in contact to work or rub upon one another.

GRINDING CONICAL SURFACES.

A CONICAL surface is ground much in the same method as a cylindrical, and with tools of nearly the same general form, but with this difference, that the grinding surfaces are made conical instead of cylindrical, and they do not admit of being traversed through each other, after the manner of grinding external and internal cylinders, to distribute and correct errors. As the grinding tool used will transfer its errors to the work, the accuracy of the result of grinding cones depends upon the accuracy of the tools employed in the process.

In grinding the external cone the work may be revolved in the lathe, and the grinding tool well supplied with oil and emery held in the hands taking care to turn and twist it around to different positions, and to traverse it endwise as much as possible, the object being to distribute the abrasive material, and thus prevent the liability of the work being ground with rings and ridges. It is necessary to make the conicalrecess of the grinding tool a little smaller than the work, as its enlargement and the reduction of the cone will, at the end of the operation, be about the intended size of the finished cone. The tool used for grinding external cones may be the same as the adjustable tool for grinding external cylindrical surfaces, and the method of casting the soft metal upon its interior may be the same as in that tool being cast in two halves upon the cone to be ground, or upon a separate cone which ought to be a little smaller than the one to be ground.

In all cases, and more particularly in conical surfaces which are hardened as lathe spindles of this form sometimes are, precisely the same angle should be made upon this work while soft as that to which it is to be when completed by grinding, only leaving it a little larger in size to compensate for the reduction occasioned by the process, and this reduction need only be sufficient to remove the distortion occasioned by the process of hardening, tempering, and case-hardening, according to which process the metal may be subjected to. Conical surfaces in brass or similar soft metal may be ground with powdered pumice-stone moistened with water.

If there be two cones joining each other upon the same spindle or piece of work, but made with different angles, a grinding tool cast to the counterpart of both forms may be first employed, and both cones ground at the same time, and this ought to be done to insure their being concentric with each other. If one cone be longer than the other, the long cone will serve as a guide for applying the tool to the more obtuse one.

Another method of grinding external cones is perhaps, more expeditious than the methods described. The work is fitted to revolve in the lathe, and an emery-wheel of small diameter is fitted to the slide-rest, or in any temporary bearings fitted to receive it, and placed with its face at the same angle as the level of the cone, and then put in rapid motion, reducing the cone as both cone and wheel revolve, but in opposite directions. Another method may consist of a bar of iron on which is a casting of lead, made to encircle about half the diameter of the cone, and, when freely supplied with oil and emery, made to move longitudinally over a distance about the length of the cone, and in a line with its angle.

In grinding an internal cone the same principles may be applied as just mentioned. The work may be revolved in a chuck or by being bolted upon the face-plate of the lathe, and the grinding tool cast in soft metal and made to fit a portion of the diameter of the cone, and by means of a slide-rest, set at a suitable angle, the grinding tool is made to traverse the surface to be ground. The revolving wheel may in some instances, be used upon internal conical surfaces.

Solid conical grinding surfaces of soft metal or brass, cast upon cylinders or rods of iron, are the means generally employed for grinding the surfaces of internal cones, but the same objections which result from grinding external cones with tools of the same size exist in the case of internal surfaces. If an external cone be fitted to an internal one the two may be ground together, being freely supplied with oil and emery, and this will insure a perfect contact; but there is a liability of the two surfaces grinding ridges into each other which may be very detrimental.

For long conical holes an adjustable tool may be used, and this tool can be made to fit internal cones upon the same plan as for grinding internal cylindrical surfaces, which can be done by means of three or more set screws inserted upon opposite sides of the halves of the divided tool. These set screws may be slackened or changed with the progress of the work, thus avoiding the necessity of employing more than one tool. In its application either the work or tool may be revolved, as may be desired or most convenient or as the nature of the work may demand.

PRODUCTION OF SPHERICAL SURFACES.

THE production of a spherical surface is not so difficult as the novice might imagine, and where a sphere detached from the supports employed in its formation is desired, it may be produced in this manner:—Center the material from which the sphere is to be produced, and after having ascertained the desired size it is intended to make it, turn a groove of this size in the material midway between the centers upon which it rotates; then remove it and fix it so as to rotate at a right angle to its former plane of rotation, fixing the centers on this groove, which will serve as a guide to remove the surplus material. As the groove which was first turned is no other than a perfect circle, if the work be properly centered when the change in its rotation is made, and the surplus material removed to this guiding groove, the result will be a form which will not vary from the spherical.

There is another method of producing a sphere by means of a tool pivoted to a rest, the pivot finding a support upon the bed-piece of the lathe at a point directly under the work, thus enabling the tool to be moved in the segment of a circle, limited in size to the distance from the cutting edge of the tool to the pivot. It is evident that as a tool moves in a circle around the pivoted end, a circle of a corresponding size depending upon the distance of the cutting tool from this pivot will be the result. This tool may be made self-acting, by placing the rest upon a horizontal wheel, which turns upon the pivoted point; this wheel may be moved by means of a gear made upon its circumference, meshing into a worm-wheel which actuates it. In turning globes and balls of wood, where rapidity is desired, a handle may be fixed to the rest, to move it and the tool, which are pivoted as first explained; the rest moving in a circular manner to form the spherical shape. The tool used for wood might be made in the form of a fork at its cutting end, and then these forked ends will cut much nearer to the centers, and remove more of the wood, so that the work approaches nearer to the sphere at these points than if it were not so made. The heads of the lathes are generally so formed that they interfere with a sufficient movement of the tool to cut very close to those parts upon which the work rotates.

There is another method of producing a sphere which is generally used by those who make the "ball cherries" used to shape the spherical recess in bullet molds. It is based upon the principle that if a rotating body be passed through a circular aperture at a right angle to its axis, a sphere will result. In this instance a circular aperture is made near the end of a flat bar of steel, as shown in Fig. 44, and great care is taken to insure the accuracy of such aperture. Upon one side of the flat bar the metal contiguous to the hole is removed so that a beveled cutting edge, and then a portion of the metal in the form of a V is also removed, so that the apex of the V enters the aperture; when thus formed, the bar is carefully tempered for use. The piece of steel from which the "cherry" is to be made is rotated in the lathe between the centers and roughly fashioned with the turning tool into the semblance of a sphere. The part which was supported by the dead center is then cut off or removed, and the work made to rotate without that support. The bar of steel in which the circular aperture is made is the place underneath the roughly-fashioned sphere, the V-shaped opening being presented to the part of the metal to which the rough sphere is attached, and

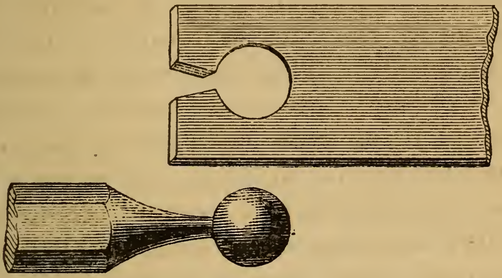

Fig. 44.

passed over or rather the sphere is passed through the aperture, the V-shaped recess admitting of such operation. The cutting edges of the tool around the aperture scrape, as it were, the surface of the sphere until it will admit of its passing entirely through, when it will present the form as seen in Fig. 45. It will be necessary that a liberal supply of oil be applied during the process, or otherwise the tool may tear the surface of the work and it will be spoiled for its intended use. Where an extreme nicety is required in the production of these spheres for making bullet molds, it is better to employ two of these tools, the first one to form the sphere nearly the size, and then use a finishing tool which has a keener cutting edge and has an aperture of the exact dimensions that are required in the finished "cherry."

To insure accuracy of the aperture in the bar of steel which is to form the sphere, as it is liable to warp or change in the process of tempering, it may be necessary to grind it to an exact circle by some of the means used to grind hollow cylindrical surfaces.

GRINDING SPHERICAL SURFACES.

The common method of grinding spheres is based upon the fact that a perfect sphere is at its every part a true circle, and if this sphere is placed within a circular grinding tool, or ring of somewhat smaller diameter than the finished sphere, and it be brought to bear upon a narrow circular portion of the ring, then by putting the sphere in rotation, and turning it equally in every direction, its prominent parts will be successfully reduced by the action of abrasive material in contact with the ring, and the result will be a perfect sphere.

The tool used for this purpose may be either of iron or brass, and its thickness equal about one-third the diameter of the sphere, and of a width sufficient to allow a conical-shaped hole to be made, sufficiently large to allow about one-fourth of the diameter of the sphere to project through the smaller end of the hole. The principle of grinding depends upon the rotation of the sphere within this ring or tool. For large spheres, the grinding tool may be made of a bar of iron with a conical hole made at its central portion, and the bar extending a sufficient length each side to form handles for the purpose of holding it, and rings of brass or other soft metal of the proper size and shape may be inserted in the large hole of the bar to form the grinding surface For a sphere of an inch in diameter, the bearing surface should never exceed one-sixteenth of an inch wide. There is more danger of embracing a too large portion of the sphere than too little, as perfection cannot be attained until the bearing surface of the tool is very much reduced.

To hold the sphere for the purpose of grinding, two revolving chucks are necessary, each chuck being indented to receive a small portion of the sphere, and both are placed so as to revolve in the same line but in contrary directions. The chucks may be made of pieces of wood screwed upon mandrels, and the speed of rotation ought to be the same for both, which can be accomplished by the spindle-pulleys being of the same size, and being driven from a drum of equal diameter at the place where the driving-belts are placed. It is necessary to cross one of the belts to produce the motion of rotation of one spindle in the opposite direction to that of the other. The internal between the chucks should be the same as the diameter of the sphere.

In grinding, the sphere is placed in the conical hole of the grinding tool, and oil and emery or other necessary abrasive material supplied; the chucks are put in rapid motion, and the sphere is slipped between them. The tool is held horizontally by the handles, and is pressed sideways against the sphere to keep the grinding surface equally in contact with it. The sphere is at the same time slowly but uniformly traversed by the grinding tool around the chucks, as the fastest rotation is at the greatest distance from the chucks between which it rotates. Notwithstanding the resistance of the tool, the simultaneous action of the chucks on the opposite sides of the sphere causes its rotation. It is obvious that the greater the speed of the chucks the quicker will be the process of grinding. Care must be taken to keep the chucks pressed close to the sphere and cause its rotation within the grinding tool, or otherwise the surfaces of the chucks may become charged with the abrasive material and act as tools to grind facets upon the sphere. The necessary amount of oil and emery is supplied while the chucks and sphere are in motion, and it must not be permitted to linger longer on one part of the circle than another, or the sphere would be ground at that part and become an oval.

The method in which the marbles used by children as playthings are produced, is first to break the stone from which they are made into suitable fragments of cubical form, and about one hundred and fifty of these are ground at a time, in a mill similar to a flour mill, the lower stone of which remains at rest, and has several concentric circular grooves or furrows made on its surface. The upper stone is of the same diameter as the lower, and is made to revolve at a little distance above it. Minute streams of water are directed into the furrows of the lower stone. The pressure of the running stone on the little fragments is to roll them in all directions and reduce them to nearly perfect spheres. About a quarter of an hour completes the operation. Instead of an upper stone, a disk of hard wood has been sometimes used with nearly as good an effect.

GRINDING PLANE SURFACES.

In hardening steel work it commonly happens that during the process it becomes more or less distorted from its intended form, and grinding must be resorted to as a means of remedying the evil. The abrading wheels used for this purpose are either common grinding-stones or some compound which contains the abrasive material in its composition ; a plane wheel of iron, lead, tin, or a wooden disk covered with leather. The stone or composition wheels require no application of abrasive material, as that is contained in its parts ; but where metal wheels are used, the abrasive material must be applied with oil, and when smeared over the surface of the flat side of the wheel, the work is applied, moving it about in different positions until it is sufficiently reduced. The wheel when covered with leather must have the material applied by means of glue or some similar substance. When it is desired to have the work present a true surface, it is necessary that the wheels be made very true and accurate. There is a constant tendency to destroy the plane surface of the wheel, because the outer part or external diameter gets the more worn, on account of the greater rapidity of the action of that part, and to obviate this it is necessary to move the work near the spindle on which the wheel turns or keep it in motion over all the surface of the wheel. It would, perhaps, be very desirable to have the finishing touches performed as near the outer diameter as possible.

As good a grinding wheel for flat surfaces as we ever used was made of a face-plate belonging to a lathe, and upon this plate was cast a heavy coat of lead, with a little tin in alloy to slightly harden it; and this leaden coating was nicely turned or finished till its surface was perfectly true, as indicated by a steel straight-edge when applied. This surface was smeared with oil and emery and the work held upon it, moving it around until it was sufficiently ground. As the wheel revolved in the air, or with no bearing to impede manipulation upon the working surface, it was found to be some advantage in applying and handling the work, and when the leaden face became worn it could be turned off and it would then last for a time, dependent upon the thickness of the leaden coating. This coating was held by the soft metal flowing into the interstices as are usually formed in all large lathe face-plates. It was at one time desired to grind the flat surfaces of a kind of valve which had a long stem, and by drilling a hole at the center of the wheel this stem could be inserted in the hole and the surface of the valve ground with great ease and rapidity. The natural grind-stone is the best means for grinding rough surfaces and then finish with metallic wheels supplied with abrasive powder, of which emery of different grades is generally used. For brass, powdered pumice-stone and water may be employed. If great accuracy be desired, a hard metallic face should be used for the grinding-wheel, as a cast-iron or brass wheel, or a wheel of similar metal coated with type metal or similar hard alloy. If a fine surface or a high polish be the desideratum, the opposite quality—softness—must be sought for, and a wheel coated with pure lead and scantily supplied with very fine polishing powder may be used, but the leaden faced wheel is preferable ; as the lead being yielding, allows the emery to become imbedded in its surface, and consequently a smooth face can be produced with emery of quite coarse grade. But when wheels of harder metal are used the emery cannot penetrate it, a portion is lost when the work is applied, and the remainder rolls over and makes scratches in the work nearly equal in depth to the size of the grains employed. Wheels for small work may be made to rotate upon any part of a spindle, but for larger work had better be fixed upon the end of a spindle which may stand in a vertical or horizontal position. As the varying velocity of the wheel decreases from the periphery to the center, and the center is liable to become less worn, then the outer surface of about one-third of the extreme diameter of the wheel may be removed or omitted in making, so as to leave a central aperture of that size.

Work that is thin may be fastened to a piece of wood, by driving two or three pieces of wire into the wood around the edges of the work, but it may be sometimes convenient to cement small or very thin objects to a brass or iron plate and remove them by warming a little when the work is done. This cement may be made by melting together two pounds of Burgundy pitch, two ounces of yellow wax or two pounds of Spanish white ; when thoroughly melted and incorporated roll into sticks. To use it melt the end of the stick by holding it near the fire and rub it upon the bit of wood upon which the work is to be attached. Warm the work to be applied, place it upon the warm cement, and it will firmly adhere. If there be no danger of injuring the work, a blow of a mallet will remove it ; but if the work be thin or of a delicate character, it must be warm, and when the cement is softened, it can be safely removed.

THE MILLING MACHINE.

It is only within a few years that the true value of the milling machine has been known and appreciated. In its infancy it was a rude machine, quite unlike the one whose form we daily see in use. The employment of rotary cutters was no doubt suggested by the idea that tools made circular in form and with teeth upon their periphery rotated upon a spindle would, if the material to be operated upon were rightly placed, cut each individual piece into forms of which one would be the exact fac-simile of another. The tools used may be considered simply as the application of the file-surface upon disks of steel, rotated instead of moving reciprocatingly.

As with all other tools, necessity was the mother of the milling machine, and the first-born implement was rude indeed. It consisted of a puppet-head attached to a wooden bed-plate ; and moving transversely with the spindle of this puppet-head was a carriage, to which the work to be reduced was attached by means of a pair of clamp-jaws. As oil was necessary to lubricate the cutters when iron or steel was acted upon, the wooden bed soon became so thoroughly saturated with oil that it was no pleasant task to come in contact with any portion of the machine. This first machine may be called an experiment, and its result was in a high degree satisfactory. The necessary curves given to different portions of metal, particularly in gun-work, in the manufacture of which this machine originated, could not well be produced by any other means. The curves and irregular shapes of such parts as lock-plates, bands, and trimmings which were let into corresponding recesses in the stock, could be readily and exactly formed and multiplied to any extent, while if the forms of these same parts were to be produced by the manipulation of the filer, it would be a tedious, elaborate, and costly production.

At the present day the milling machine is a finished tool, and an ornament to the shop it occupies. It operates with certainty and works strong and smoothly, and is capable of enlargement to almost any extent. As its origin is due to the gun-factory, it was in the manufacture of arms alone that it has been used for many years. We think that the next place in which it was employed was in the sewing-machine factory. And here, as in gun-work, many duplicate pieces were required precisely of the same form, and no other tool could so produce them. Outside of these two employments, it is only at a late day that its value has been observed and its merit become known in other trades. In the jobbing machine-shop we begin to see that the milling machine has a value, and that with it and a few cutters many forms of work can be produced at a cheaper rate and in a better manner than by either planer or lathe.

The great value of the machine seems to have been its adaptability to produce irregular forms which are exact similes of each other; but it is also applicable to the squaring-up of the ends of rods and bars of iron, the forming of spline and key seats, shaping nuts and bolt heads, the cutting of geared wheels and the making of the cutters which produce this work, the fluting of reamers, and making twist drills, which are costly to purchase, but by the milling machine may be cheaply produced. These are but a few examples of its capability. The usual planer fixtures can be adapted to hold the various kinds of work, and other appliances adapted to peculiar forms of work can be easily fitted by a mechanic of even common ability.

MILLING MACHINE CUTTERS.

It is the custom to make a certain class of milling machine cutters of a single piece of steel, which is used singly upon the machine spindle, while in other cases several cutters of different sizes and shapes are placed side by side upon the same spindle, and form what is called "a block" of cutters. These cutters are turned to the proper shape and thickness, and numerous teeth made extending in an axial or spiral direction around the circumference of the cutter. These teeth are cut by means of a planer or a revolving cutter of the proper shape. It often happens that some portions of the work upon which these cutters are to be engaged are deeper than others and of irregular forms, in which case a block of cutters is used of the opposite form, and when in motion they act as a single cutter. This method of forming cutters, consisting of a series instead of a single one, has, especially where a wide cut is to be taken, many advantages, inasmuch as many of the irregular forms could not be produced by a single cutter, and if at any time a cutter becomes injured or broken, as will often happen, it can be readily removed and a new one substituted. In tempering there is less danger of the cutters warping or twisting when thus separately made to form a series than there is when the large and irregular form is of a solid piece of steel. It is also easier to cut the teeth in thin or narrow cutters than it is in the broad irregularly-formed ones, and also easier to grind and keep them in order when they are dulled.

In forging the steel for cutters for the milling machine care must be exercised not to overheat the steel or to compress it by forging more in one place than in another, as the density of different portions, induced by the unequal forging, will tend to make it spring when it is hardened, and where a block of cutters are placed upon a spindle and confined by a nut being screwed up to hold them fast, the irregularities caused by springing in tempering will cause the spindle to spring so that the cutters will present eccentric instead of concentric circles in their rotation, and the irregularities of shape will divide the labor of the cutters unequally, as the most prominent portions will do the work, while the less prominent perform little or nothing of the labor. As a consequence, the work is not left so nice, and the operation is attended with more risk of breaking the cutter.

If by chance a cutter should be sprung in tempering, it may perhaps be brought true by grinding its sides, but it will be done at the expense of diminishing its width.

As to the best shape for the teeth of cutters no two experts will agree, as one will prefer one angle and another a different one ; but on one thing all are agreed, and that is in forming the teeth much thinner than in common turning tools, and also in shaping the teeth so as to give sufficient release for the cuttings, or the spaces between the cutting points will become clogged with the metal removed while in operation. The speed at which these cutters should revolve should be about the same as the same material to be cut would rotate in the lathe if so placed for turning.

While the cutters are engaging the work which they form or reduce, oil is supplied to them to prevent their being destroyed by the heat which the friction would otherwise induce. As the strain produced upon the cutter is quite considerable, the line of the teeth ought to be made in the form of a spiral, so that if a line be drawn upon the circumference of the cutter in the same direction as the line of its axis, one tooth will commence at this line and the subsequent tooth will end at it. This will distribute the strain evenly over the teeth, and they will be less liable to break and a heavier cut can be taken.

As some trouble may be experienced in turning up the blanks, if they be of irregular form, of the proper shape by means of a template, a simple operation may be adopted which will save a great amount of labor. Turn the cutter blank or blanks roughly into form in the lathe, and then remove them to the milling machine and fix them as they are to be used when finished. Make a pattern of a stout piece of steel of the *exact* profile form the cutter is to produce in the work. Slope one edge of this pattern back a few degrees so as to make a stout cutting edge, and nicely temper it. Screw it in the vise or jaws of the machine, where the work is to be inserted, and fix it in the same manner as the work is to be placed. Then set the machine running, and, using a very light feed, run the pattern just under the blanks, high enough to enable it to remove a portion of the intervening surface. If it be not reduced enough, then decrease the distance until the pattern produces its reverse exactly. The blanks can then be removed and the teeth upon the mill or cutter made and tool tempered for use.

SELECTING STEEL FOR TOOLS.

THREE requisites are necessary in the selection of steel for tools, and those requisites are hardness, tenacity, and properties of working in a heated state, as forging or welding, but these properties vary according to the amount of carbon contained in the steel. Pure iron contains no carbon, while steel suitable for tools or instruments with cutting edges contains less than two per cent., but so small is the amount of carbon necessary to adapt steel to the purposes for which it is intended, it is not to be wondered at if the supply, as received from different makers, should vary in its character and quality, and that some experience is necessary to select steel suitable for particular purposes. Those who are experienced and manipulate the metal can readily judge of its character and composition, with a sufficient degree of accuracy, so that it is not essential to submit the metal to a chemical analysis. Good cast-steel will not bear a high heat without injury, and when this heat is raised to what is termed a "white heat" will fall in pieces upon receiving the slightest blow; even at a bright red heat it will sometimes crumble under the action of the hammer. When heated to a "cherry-red" it can be wrought with safety, and can be drawn to a very fine edge or point. Inferior steel, on the contrary, whether at a high or low heat, will not so crumble, but in its action will approximate to good wrought-iron. One of the tests to distinguish steel from iron is nitric acid, or, as formerly termed, aqua fortis; when the acid is applied to the clear metallic surface it will leave a black stain upon steel, but will not so color iron.

Tools requiring a fine firm edge must be made from superior steel, and as a hint on the selection of such steel, break a bar and observe the grain, and select that which is fine, and when this bar is somewhat hardened, as it usually is when received from the manufacturer, this fracture should present a dull silvery appearance, more close than soft steel, and of a uniformly white color. Indifferent steel will also show a close grain, and expert judges are sometimes deceived. Perhaps the best test for steel is in the forging and working, as its character can be then pretty plainly demonstrated. Steel that will not take a fine point will not receive a fine firm edge; when a bar of steel is drawn to such a point, hardened, and gentle blows given by a hammer, its tenacity is shown, and when broken its value for cutting tools is pretty evident. These qualities of hardness and tenacity combined are also plainly shown by hardening a small bar or rod of good cast-steel, and a similar rod of inferior steel. The former will require some severe blows to fracture it, and will present a fine lively appearance when broken, while the rod of inferior quality will break upon the least blow, and the fracture will be dull and as it were lifeless.

The severest use to which a cutting tool can be put is in the form of a cold-chisel, and used upon iron castings or similar work, and this usage will test the goodness of the qualities requisite in the metal. The blows given in such work fully test its tenacity and hardness, and if it will satisfactorily perform its duty in such operations there is but little fear that it will give way when formed into cutting tools which are not subjected to such rough manipulation.

FORGING AND WELDING STEEL.

In heating steel, preparatory to forging or other working, the degree of heat imparted by the fire in which the steel is inserted is commonly judged by the eye, and, as the heat required to work steel diminishes with the increase of carbon it contains, it consequently requires great caution to heat and work it so that it will leave the hands of the forger uninjured. In comparison with iron, steel will bear less heat; but, when worked at a low temperature, iron cannot be wrought without injury, whereas steel is improved by it, and its tenacity and fineness are much increased; but if again heated to a high degree this effect is removed. Precise instructions cannot be given, either written or verbal, concerning the manipulation of steel, and actual experience in working begets a knowledge of its temperament which can be learned in no other way.

The heat which can be used with the greatest safety in working steel is called the "cherry," so denominated from its resemblance to the color of that fruit, and two divisions may be made of this heat, called the "high" and the "low," and this latter heat is sometimes called a "blood-heat" or "blood-red." Too frequent and too high heating abstracts the carbon from the steel, and reduces it to a state approaching that of iron. As the temperature of steel is increased, its affinity for oxygen is increased, and when heated to such a degree a scale is formed, and as this scale is removed a portion of the carbon of the steel is extracted. At a low heat the affinity of the carbon for oxygen is very slight. When once deprived of its carbon by overheating, it may be somewhat restored by heating and hammering ; no degree of heat or no amount of hammering can restore to it the carbon, or give to it its original form of texture.

For cutting tools, while they are in process of forging, the steel should be hammered equally throughout, and the process continued until the metal is nearly cold. This should be observed especially during the last heat given to the articles. Equal forging will, in some measure, tend to prevent warping when the tools are tempered, as equal strokes and alike distributed, will equally compress the metal, and the expansion and contraction attendant upon the heating and cooling will be correspondingly equal. If steel rods or bars, as produced by means of rolls, be heated and cooled, or tempered, these will have less tendency to warp than if these same forms be produced by the forging hammer. Examples of this are seen in drills and tools and as made from rods of steel, in which no hand forging has had a part in their formation. Twist drills made from steel wire seldom warp so that they are incapable of being used. If tools be made from the steel as received from the rolls, by first annealing it, "roughing out" the tool in the lathe, then anneal it a second time, and then finish it, but little fear of warping may be apprehended, especially if in tempering it be evenly heated and as evenly chilled.

To weld steel without injury to it, is an operation which requires some nicety of management and judgment to perform. The smaller the proportion of carbon and the greater the fibrous texture of the metal, the easier will be the operation of welding. Mild steel, as shear-steel, containing a less proportion of carbon, welds with less difficulty than highly carbonized or cast-steel suitable for cutting tools. The fibrous texture of cast-steel being destroyed by the operation of fusing, it is more difficult to weld than steel which has not been subjected to this process. The more fusible the steel the less easily it welds.

In welding together bars, or pieces of steel, the sand usually employed as a flux for iron must be discarded, and borax employed in its stead, and for this reason the sand requires a greater heat to melt or fuse than the welding heat of the steel ; for if steel were heated so that the sand would be sufficiently fused to act as a flux, the steel would be badly injured. Some of the cast-steels require a still more fusible flux than even borax, and the sal-ammoniac is mingled with the borax. One part of sal-ammoniac to fifteen or twenty of borax is sufficient. The best and most economical mode to use borax is to put it in an iron kettle or ladle over the fire and heat it until it discontinues to "boil up," which announces that it is sufficiently calcined, and then pulverize it by some suitable means. The use of sal-ammoniac also tends to clean the dirt from the steel, and the borax causes it to fuse before it attains a heat that will burn it.

A clear bright fire must be used during the operation of welding, and the presence of foreign metals, as lead, tin, brass, etc., must be rigidly guarded against. When the steel is somewhat heated it is withdrawn from the fire and the powdered borax applied, and when again inserted, the heat is raised as high as the steel will bear without injury. When at the point of fusion it is quickly taken from the fire, placed upon the anvil, and manipulated much in the same manner as iron. The blows to effect the unity of the welding are given gently at first, but are increased in force as the cohesion increases. If once heating does not produce the necessary union, the process of heating application of the borax must be repeated until the joint is perfectly sound.

EXPANSION AND CONTRACTION OF STEEL.

It is well known to workmen that by the process of hardening steel it is sometimes considerably enlarged, and work that was nicely fitted in its soft state is so expanded by the heating and chilling process that it will not fit places where it was intended, and grinding must be resorted to in order to produce the fit required. It is impossible to state the amount of this expansion, as it varies according to the size of the piece of steel, the amount of carbon it contains, and some on the degree of heat applied. The greater amount of carbon and the higher the degree of heat applied the greater will be the expansion, and the nearer the steel approaches to the character and quality of wrought-iron the less will be the expansion.

Where the expansion of steel would be guarded against, as it cannot be wholly prevented, the work may first be roughed out, either in the lathe, planer or by means of the file, as is most applicable, and is characteristic with the article, and then carefully annealed; then when cool go over it again in like manner, and if great precaution be needed repeat the process a third time. It may seem tedious to thus repeat this process, but where great accuracy is required and the articles are of such shape that they cannot well be ground to the form, it is better to thus carefully proceed than to run the risk by the non-observance of this process. It may be observed that tempering articles after they are hardened somewhat reduces the bulk, but this is too trivial to be taken into account in common practice.

Contraction is also another peculiarity of hardened steel, anomalous as it may seem, and while some articles of one form expand in hardening, another class will contract, and this is explained, upon this fact, if the article be so large that the interior portion be not chilled by the immersion the result will be expansion, but if the article be small or of such form that it is chilled equally throughout, then the result will be contraction.

This faculty for contraction can be taken advantage of by the workmen ; if, for instance, he has a circular cutter or similar form of tool or appliance and the aperture should be made too large, and it is imperatively necessary to reduce it, then by heating the article and chilling it the contraction will be such that the aperture will be considerably reduced. A repetition of the operation will again reduce the aperture. This may be done by two or three times heating, but after that the aperture will tend toward elongation rather than equal contraction. Where ring gauges are used and become worn by usage, this method may be employed to reduce them to their original dimensions. If by hardening they are too small, they can be enlarged by grinding. Where drilling gauges of several inches in length are made, having two holes, one at each end of the gauge, and if by any oversight or want of accuracy these holes be too far apart, they may be brought to the proper distance by careful heating the gauge and then quenching it in water. Annealing or drawing the temper will not restore the metal to its original dimensions. Gauges and similar tools are often thrown aside as useless, when a knowledge of this fact might enable them to be so contracted that they might be made to subserve as good a purpose as new tools.

ANNEALING OF STEEL.

We have often noticed that, after the smith had finished his work and wished to leave the steel or iron forging in a condition of sufficient ductility for the lathe workman or filer to operate upon, he would carelessly heat the forging and either insert it into the ashes and coal-dust of the forge or heedlessly throw it upon the ground beside the anvil-block; consequently when the turner or filer begins his work he finds it full of small hard spots, some of them exceedingly minute, and technically called "pins," which spoil the cutting edges of his tools and destroy his files. Finding it impossible to proceed further in his manipulations he takes the unfinished article from the lathe or vice and sends it back to the forger to be re-annealed and returned to him. We have seen this process repeated two or three times on some kinds of work, when a little knowledge and care would remedy the whole thing.

In annealing, the steel should be heated slowly and carefully, as there is as much danger in overheating as there is in forging, and the whole article must be thoroughly heated through, and brought to no higher temperature than a "light red" heat. If the article is long like a spindle, it must be turned frequently in the fire, to prevent its warping or becoming sprung by the unequal expansion upon its sides; and at the same time be careful to heat it equally the entire length. The forger ought always to have an iron box of dry powdered charcoal by his forge, and in this quickly insert the article that is to be annealed, and cover it close with the coal-dust, so that the air cannot come to it, and there let it remain until perfectly cold and no sign of warmth be perceptible. If this is carefully done, the lathe workman or the filer will have no cause of complaint about "pins" in the course of his operations.

Some forgers bury the articles that they wish to anneal in powdered or air-slacked lime, cast-iron borings, saw-dust, etc. These may answer a very good purpose, but they are in no way equal to the box of charcoal dust.

There is another method called "fire annealing" that is practiced to some extent. It consists in heating the steel to a red hot and then holding it in a dark place until a faint glow of heat is seen upon it, and then quenching the heat that remains in it in water. This may answer when there is need of the forging to be wrought upon immediately, but it is an operation that we do not approve of, and is not as effectual as the operation that we have described with coal-dust. Let any one who works in steel try the various methods, and they will give a hearty approval to the box of charcoal dust.

HARDENING OF STEEL.

SKILL and judgment in the manipulation of steel are qualities of which the expert workman may well be proud, yet there is nothing so difficult about it but that by patience any one of common abilities may become the possessor of it.

The forging of steel tools requires great care, and for delicate instruments that are to be nicely tempered too great care on the part of the workman cannot be exercised. The quality of the steel ought to be attended to, particularly for dies or cutting tools. Of this you can judge in a great measure by the fracture. Break the bar you wish to work. If the piece presents a clear, bright cleavage, that shows as if it had taken some force to separate it, the separate crystals or granulations scarcely observable, and the appearance that of a fine, light, slaty-gray tint, almost without luster, it may be considered to be good.

After the tool or article that is to be tempered is finished up by the mechanic, it is to be hardened. To the inexperienced it appears to be a simple operation, and one that any one could easily perform, consisting in nothing more than heating it and suddenly quenching the heat in cold water. A very simple process surely; then why so much ado about it? Surely the greenest apprentice can do it. So he might; but perhaps when the said apprentice takes the tool from the water in which it has been chilled it is warped, cracked, and entirely spoiled. The once nice tool is now only fit to be thown in the scrap-pile. Surely, after all, it *does* require *some* experience and judgment to temper steel. We will give a few hints that may not be wholly lost to the less experienced who aspire to success in this art.

The water that you use must not be too cold, and the steel must not be too hot. The heat should *never* exceed a low red. The reason why the water should not be too cold is this:—The water acts too suddenly on the outside of the steel, contracting it, and the expansion in the middle being more than the outside can bear, it causes the hardened and brittle covering to break. If the water is too cold throw a few coals into it, or plunge a bar of hot iron into it and take the chill off the water. When this is done, look well to the heating of the article, heat it quite slowly and very evenly, and, when it is ready to harden, if there is a thick and thin part, plunge the thickest part into the water first, and be careful to plunge it in the center of the vessel of water, so that the heat of the article will warm it equally on every side—if not, the unequal warmth may cause the article to warp. A worse thing will happen if the thin edge be put in first, for if the thick part has to contract after the thin part is chilled, the thin part cannot give, and will be consequently broken. By chilling a piece of steel and lifting it from the water before it is entirely cold, will produce the same effect. The outside being hardened and the inside quite hot, it begins to expand when taken from the water, and the breaking of the chilled surface is the result. In dipping articles in water that one part requires to be left soft, it often happens that it breaks where the water-line comes on the article. This is caused by the contraction of the portion in the water while that above the water is not contracted in the same proportion. To remedy this, move the article up and down a little, so that the water-line shall not be at a stationary point. This will be particularly applicable to tempering points of drills and chisels.

Water that holds soap in solution is unfit to temper with. The water should be clean and pure. To insure a greater hardness, common salt may be added to the water so as to form a saline solution. Gauges and burnishers that require to be very hard can be tempered to advantage in this solution.

HARDENING AND TEMPERING STEEL TOOLS.

THERE is scarcely an operation in mechanics which is performed with greater hazard than that of hardening and tempering tools; for if the operation be unskillfully performed, the whole labor of forging and finishing the tool, together with the value of the steel employed, is in an instant wholly destroyed and lost, and nothing avails but to perform again the labor and produce another tool.

The dangers to which steel is liable in the process of hardening are warping and cracking. The first may be caused by unequal density in forging, one portion of the steel being more compressed than another by the hammer-blows, and unequal contraction ensues when the hardening takes place, which causes the article to warp or twist. Another cause of warping is when the thick and thin portions of the metal are so proportioned that in the shrinkage the thinner portion is forced to one side or pulled away, as it were, from its proper place; and this may take place to such a degree as to cause the article to crack in a greater or less degree. Too high a heat or too great coldness of the bath in which the articles are hardened may produce these results.

As a remedy for warping from unequal forging care must be exercised by the person who executes this portion of the work, or steel may be used which has been formed by rolling or by means of the drop and die. As an instance to verify the truth of the assertion that rolled or drawn steel seldom warps, we may mention the twist drill as made from steel wire. The density of the metal being homogeneous in all parts, it seldom warps or springs in hardening. Where an article is made with thick and thin portions the best remedy is skill and judgment. The thick part must be chilled or come in contact with the water first, and by its first contracting it cannot bind upon the thin part so as to cause it to give way. It is difficult to give precise directions for such operations, and the best suggestion is that the person intrusted with such tools to harden should be possessed of judgment and experience in these operations and have a knowledge of the nature of the material with which he is dealing. Even in placing tools which have unequal proportions in the fire, a springing or warping may be produced by one portion expanding more than another, and as much care is to be exercised in heating tools as in hardening.

With the successful hardening of tools or other articles we may consider that the greatest danger of destruction is past, and all that now remains is to reduce this hardness to the proper degree, or "draw the temper," as it is technically termed. Between the extreme conditions of hardened and soft steel there are many intermediate grades, the index of which is oxydation or "coloring" of the brightened surface when heat is applied.

The brightening of the surface is accomplished by the mechanic in many ways. A piece of sandstone or grind stone, or even a fragment of brick, is sometimes employed. The buff-stick, which consists of a piece of wood shaped like a file and covered, generally, with leather, but often not, and the surface coated with glue and emery, the glue holding the emery in place, is another means often used; but the best of all is the polish-wheel, where a sufficient number of pieces or articles or the nicety of work will warrant of such procedure in its use.

The tints or colors are produced upon the polished surface upon the application of heat, and the respective approximate temperatures, may be represented thus:—

1.	430	degrees	Fahr.,	very pale straw yellow.
2.	450	"	"	a darker shade of yellow.
3.	470	"	"	darker straw color.
4.	490	"	"	still darker straw color.
5.	500	"	"	brown yellow.
6.	520	"	"	yellow tinged with purple.
7.	530	"	"	light purple.
8.	550	"	"	dark purple.
9.	570	"	"	dark blue.

10. 590 degrees Fahr., pale blue.
11. 610 " " still paler blue.
12. 630 " " paler blue with tinges of green.

The tempering colors differ slightly with different qualities of steel, some kinds of which require a higher degree of temper or color than others to obtain the same degree of hardness ; but a knowledge of this can only be obtained by actual experiment. In the table given Nos. 1 and 2 are used for tools to cut metals ; 3 and 4 are used for the same purpose where more elasticity is required ; 5, 6, and 7 are used for tools employed in cutting wood ; 8 and 9 for springs, and 10, 11, and 12 are too soft for any of the mentioned purposes. Many mechanics employ colors or tempers a degree or two lower than these mentioned, and use a sort of general color for certain kinds of tools, making an "average" as to color and quality of steel ; but with the mechanic who is at all fastidious about the temper of his tools or where a very particular temper is required, as in gravers, chasers, etc., the quality of the steel must be taken into consideration, and the hardening and tempering intrusted to none except the most expert in such operations.

TEMPERING STEEL IN THE LEAD BATH.

Every mechanic accustomed to heating steel for hardening in the common forge fire, knows how difficult it is to heat evenly any article that has a thick and thin portion, so that the thick part shall be evenly and thoroughly heated without overheating the thin part. Now, if the lead bath, heated to a proper temperature, be used, anything immersed in it, no matter how thin or how uneven the thickness, will if sufficient time be given be equally heated throughout.

A cast-iron pan will do to make the receptacle of the molten lead of which the bath is composed; but a black-lead crucible is preferable, but it must be handled with care to prevent breaking; vessels made of malleable iron, however, are preferable to either the cast-iron pan or black-lead crucible. To prepare the bath, put the necessary quantity of lead in the vessel and bring it to a molten state; continue the heat until it shows a blood-red glow. As lead slowly oxydizes at a red heat, some precaution may be taken to prevent it, and then the loss will be quite small. This precaution may consist of a plate of iron, say about one-fourth of an inch in thickness and laid carefully upon the surface of the lead, where it will be sustained; a hole may be made in the iron in which the articles may be introduced to reach the bath underneath it; or in place of the iron plate, the surface of the bath may be covered with a layer of charcoal in the form of dust, or a quantity of wood-ashes will answer quite a good purpose. The debris and scrapings of the charcoal bin are just the material, and the only cost will be the trouble of collection from the place of deposit.

For thin cutting blades, such as razors, surgical instruments, springs, etc., this bath is especially adapted. The only care required is to keep the bath at the proper temperature, and see that the articles immersed in it are sufficiently heated. From the lead bath they may be chilled in either water or oil, as may best suit the purpose for which they are intended.

In some kinds of work it is necessary that one end or a certain portion of the article should be left soft. This is generally done by only hardening the part or portion necessary to be tempered, but by so doing much risk is accompanied in the operation by the article cracking at the water-line of the article when immersed, in consequence of the sudden contraction of the chilled article. A much better way is to temper it without regard to the part to be left soft, and then immerse this part in the lead bath and *draw it*, as the term is, to the required state. An instance of this application is the end of steel ram-rods for rifles, where the screw is cut for the purpose of screwing on the wiper with which to clean the rifle. The rod is tempered the entire length, and the end where the screw is to be cut is immersed in the molten lead about the depth of an inch and left to cool gradually, and then no trouble is experienced in cutting the screw, which otherwise would be impossible or attended with the destruction of the cutting dies. It is sometimes necessary to soften portions of hard-drawn brass wire or steel wire that is used for springs, and to soften the whole spring destroys the necessary elasticity. If the ends of the springs are to be bent or riveted, the lead bath presents the necessary means of softening for that purpose.

We recollect having seen a process of tempering the steel springs of crinoline, by first running the flattened wire from a reel through the fire, and then into a reservoir of oil to harden it, and then passing it direct from the oil through a bath of molten lead. A reel and winch was the means used to draw the spring from the reel on which it was wound direct from the rolls through the triple baths of fire, oil, and molten lead; the judgment of the operator regulating the heat of the necessary fires and reeling it faster or retarding it as was required for the necessary temper.

TEMPERING SPRINGS.

A KNOWLEDGE of the art of tempering springs is of some importance to the mechanic. There is, perhaps, no kind of tempering that requires so much care in manipulation as getting a good spring temper. It is necessary that the spring be carefully forged; not over-heated and not hammered too cold. The one is as detrimental as the other. To insure a spring that will not warp in tempering, it is requisite also that both sides of the forging be wrought upon with the hammer; if not, by the compression of the metal on one side more than another, it will be sure to warp and twist. We will suppose that the article has been carefully forged, finished up, and is ready for tempering. Clean out the forge and make a brisk fire with good clean charcoal, or if bituminous coal must be used, see that it is well burned to a coke, in order to free it from the sulphur that it contains, as sulphur will destroy the "life" of the metal; then carefully insert the steel in the fire and slowly heat it evenly throughout its entire length. Give it time to heat through its thickness, and when the color shows a light red, plunge it evenly into lukewarm water, or water from which the cold chill has been taken off, so as not to chill the surface of the metal too quick before the inside can also harden, and let it lie in the water until it is of the same temperature as the water. A much better substitute for water is a good quality of animal oil—whale oil or lard oil is best; as a substitute we have used lard, by melting it before we inserted the heated steel in it. The advantage of using oil is that it does not chill the steel so suddenly as water, and there is less liability to crack it. Remove the hardened spring from the water after it is sufficiently cooled and prepare to temper it. To do this make a brisk fire with plenty of live coals and then smear the hardened spring with tallow and hold it over the coals, but do not urge the draught of the fire with the bellows while so doing; let the fire heat the steel very gradually; if the spring is long, move it slowly over the fire so as to receive the heat equally. In a few moments the tallow will melt, then take fire and blaze for some time; while the blaze continues, incline the spring or carefully elevate either end, so that the blaze will freely circulate from end to end and completely envelope it. The blaze will soon die out; then smear it again with tallow and blaze it off as before. If the spring is to be subjected to a great strain, or it will be required to perform much labor, it may be lightly blazed off a third time, and if it is to be exposed to the vicissitudes of heat and cold it must be left to cool of itself upon a corner of the forge, and not cooled by putting in water or throwing it on the ground.

Spiral springs of steel wire such as are used for spring balances, are tempered by heating them in a close vessel with animal charcoal or with bone-dust packed around them, similar to the process of case-hardening ; and when thoroughly heated, cool them in a bath of oil and proceed to temper them by putting a handful of them in a sheet-iron pan, with tallow or oil, and agitate them over a brisk fire. The tallow will soon blaze and the agitation will cause them to heat very evenly. The steel springs for fire-arms are tempered in this manner, and may be said to be literally " fried in oil." If a long slender spring is needed that requires a low temper, it can be made by simply beating the soft forging on a smooth anvil with a smooth-face hammer. By this means the metal will be sufficiently compressed to form a very good spring without further tempering. Use a light hammer in the process and " many blows," and a spring will be made that will last for a long time, especially if it has to bear no great portion of labor in its action.

DAMASCUS STEEL.

When cutlery, swords, gun-barrels, etc., present a variegated or watery appearance, as of white, silvery, or black lines, crossing, interlaced, or running parallel with each other, they are called "damascus" or "damaskened," and the term is equally applicable to iron or steel when presenting this appearance.

The derivation of the term is from the city of Damascus, in Syria, where swords of a superior quality and presenting the variegated appearance above-mentioned were formerly manufactured, and the modern term "Damascus" is now applied to metals so united as to form imitations of the genuine Damascus manufacture. At the present day the art of thus uniting the metals or imitating them is almost exclusively confined to the manufacture of smooth-bored gun-barrels for the use of the sportsman. The genuine Damascus is supposed to be a highly carbureted steel, which by cooling, a division of two carburets takes place, and the separation is clearly visible when the surface is corroded by the acids, as the parts acted upon by the acids are deepened and dyed by the exposure of their carbon. The damask of commerce is but an imitation of the genuine, and one method of so doing has been to smelt soft iron with charcoal, tungstate of iron, nickel, and manganese. If fifty parts of iron and one part of lamp-black be smelted together, it will also produce a good imitation. If iron plates of different natures, or hard and soft iron, be smelted together, it will also produce a damask. If oxydized iron filings and iron are smelted a beautiful damask is the result. The gun-barrels of commerce are made from a mixture of stub nails and clippings of steel of any proportions to suit the fancy of the workman; the mass is puddled together, made into a bloom, and submitted to the necessary process of manufacture. Sometimes bars of iron and steel are piled in alternate layers and welded together, and after the mass is drawn out it is twisted, doubled and twisted, then welded and drawn out again. When it is to be formed into a gun-barrel, it is drawn into a thin ribbon of an inch or two in width, which is coiled spirally around an iron rod and carefully welded, the rod being withdrawn when the weld is complete. By a close examination of a Damascus or twisted gun-barrel these spiral weldings will be observed. There are many imitations of the Damascus which are the result of corrosion or coloring with acids. One method is to partly cover the barrel, after it is brightened up, with twine wound in a spiral direction and then wet it with acids. The exposed portions of the barrel will become oxydized and the polished portions protected by the twine will remain bright. Another method is to cover the barrel with a thin coating of wax, and with the point of a graver cut through the wax so as to expose the bright surface of the metal and then submit it to the action of the acids as before; when the exposed portion is sufficiently oxydized the wax is removed and the barrel finished up. By this last process names or designs can be made upon tools that are polished, and it is often done by mechanics to prevent the loss of their tools, by their being taken by other workmen by mistake, or to recognize them if lost. The cylinders of pistols were at one time etched or engraved in this way; but in later years this ornamentation of cylinders has been produced from an engraved cylinder mounted in a frame; the cylinder of the fire-arm being rolled in close contact with the engraved one. By this means a transfer of the engraved picture or design is produced.

"CASE-HARDENING."

CASE-HARDENING is the superficial conversion of iron into steel, and combining the hardness of the latter with the toughness and cheapness of the former. Iron is tenacious and ducile, but by case-hardening it has this same tenacious body with an exterior coating of steel, produced by the action of heat and animal carbons, shrunk, as it were, over its surface, compressing the iron body, thereby producing a greater strength. It is not for economy alone that articles of iron are case-hardened. They are stronger and more durable than if made wholly of steel.

The most common articles of case-hardening that are met with are the locks, mountings, etc., of guns and rifles. To make the lock-plates and hammers of steel would be attended with many disadvantages as well as an advanced cost, not only the price of steel over that of iron, but the difficulty of working requiring more care and more experienced workmanship. If these parts were made of steel they would require to be hardened, and, as steel can only be hardened throughout its entire thickness, there would be great risk of breakage from accidental blows and changes of atmosphere. But being made of iron and case-hardened, it has the tenacity of the iron and hardness of tempered steel; the steel surface extending to a greater or less depth according to the time it remains in the hardening material.

Cast-iron is as easily case hardened as wrought-iron, and drill-chucks or face-plates thus treated are rendered of as much utility as if made of tempered steel, and at scarcely one-tenth the cost. Malleable iron has also the same properties of case-hardening that wrought-iron has, and the greater portion of gun and rifle trimmings are thus made and case-hardened.

Prussiate of potash answers a very good purpose for superficial case-hardening, but it produces only a thin film or skin of hardened surface. Any animal charcoal will answer. Burnt horns, hoofs, bones, etc., will make animal charcoal. Scraps of leather, old boots and shoes, burned in a pan in the common forge of fire and reduced to a powder in a mortar with an iron pestel are a ready means for preparing this carbon. Ground bone-dust as it comes from the agricultural stores is the most ready as well as the cleanest form of material. The bone or ivory dust does not need burning. The articles to be hardened are put in iron boxes and the bone-dust well packed around them. Care should be taken that the articles do not touch each other. The box must be tightly closed, luted with clay, inserted in the fire, and brought gently to a red heat. If the articles are large they require more time than if they were small or thin. After the box becomes hot, it will require to remain from half an hour to two or three hours, the mechanic exercising his own judgment as to time in the size of the articles. When properly heated, draw from the fire and quickly empty the contents into a bucket of moderately cold water, taking care that the work comes to the air as little as possible.

A very good substitute for iron boxes are short pieces of gas-pipe, with a plug screwed into one end and the other end covered with an iron cap and luted with clay so as to be air-tight. When the articles can be conveniently packed in pieces of pipe they are preferable to iron boxes for the reason that they are more readily turned in the fire and are more easy to handle. After the work is hardened, if it is required to polish it, proceed the same as with iron on steel. When the work is polished or burnished before it is case-hardened it will, after the operation is completed, present a variety of mottled tints that are pleasing to the eye. Many prefer the work left in this condition, as it will not rust so readily as if polished.

If a portion of an article is to be kept in a soft state and the remaining part to be case-hardened, the portion to be left soft can be covered with a thick coat of moist clay, so as to prevent the material in which it is packed from coming in contact with it. If there is thought to be danger of small articles cracking by the immersion of them in the water, a film of oil poured on the water, which must not be too cold, will prevent a too sudden contraction of the metal and the articles will not crack.

BOLT NUTS.

In purchasing bolt nuts, as they are usually kept for sale at the hardware-stores, we find them made from two kinds of iron, called wrought and malleable. The former is the usual wrought-iron, as its name indicates, and the latter is cast in sand-molds and afterwards made malleable by heat. Of the nuts made from wrought-iron there are two varieties, one of which is made by the process of cold punching and the other by the usual process of heating and forging.

If we examine either of these kinds of nuts, we find them left with a rough and unsightly exterior, and in order to have them present the same appearance as finished work, which they must accompany, some labor and skill must be applied, by filing or other means, to give them an exterior at all compatible with their position upon nice work. In fact, to finish up a nut with the file so that it will present a good exterior requires some practice and skill. The sides of the nut must be made true, and the angles, let them be square or hexagonal, must be of equal proportions and have the same appearance. The top of the nut ought to be made convex in form, and this is best accomplished by so turning it in the lathe. If a sharp turning tool be used and a few drops of water be used to lubricate it, a nice and glistening surface can be produced which is very pleasing to the eye. No better means than this can be applied to finish this convex surface.

As a substitute for filing up the sides of nuts, we would recommend the application of the milling machine to reduce the rough surface, and then finish with the file or polish-wheel, as may be desired. As a substitute for the milling machine, some appropriate fixture may be attached to the lathe which would effect the same purpose. By means of two cutters revolving upon the same spindle, the two opposite sides of square or hexagonal nuts can be cut at the same time, then by once turning the nut and cutting again finishes the square nut, and two turns and two cuts complete the hexagonal. By thus placing the nuts upon a stud and so reducing them, their opposite sides will be equi-distant and parallel. A very small amount of filing will then suffice to form them into well-finished nuts. We have often thought that nuts finished in this way might be a profitable article of commerce. And where the business is made a specialty and the milling machine or other tools employed, they can be produced with rapidity and quite cheaply.

Another improvement might be added, especially upon the forged and cut nuts, and that is to remove the inner surface of the hole in which the screw is to be cut by means of reamers, before the screw is made. The rough scale of the forged nuts and the vitreous sand adhering to the cast nut are fatal to the cutting-edges of screw-taps if they be not removed ; but this precaution is not often attended to by mechanics. If bolt nuts, with these operations performed, were presented in the market, they would be acceptable to the majority of mechanics, who could only so finish them at some expense.

THE FORM OF BOLT NUTS.

It is but a few years since that all bolt nuts were made by hand, as they were needed, by the blacksmith, and his tools for making these nuts consisted of no other, excepting the forge, bellows, and anvil, than his hammer as a means of force, a punch to form the necessary hole through the nut, and a chisel with which to cut the nut from the bar of iron from which it was made. The making of these nuts was very primitive indeed. A bar of iron of the diameter and width of the nnt was selected, inserted in the fire and heated, the punch driven through at the required distance from the end of the bar the necessary length to form the nut cut off, which was again inserted in the fire and heated, and was finished by hammering it into a square form, the punch being inserted in the hole of the nut as a means of holding it and to keep the hole of the proper form.

The *square* form of the nut was selected as the most ready to make and the easiest to be operated upon by the rude wrenches of that period. The beauty of the proportion of the hexagonal nut might at times be seen and admired, but it was of too difficult a construction to be often attempted with those rude tools and appliances, and if so made, was liable to have its corners abraded by ill-fitting wrenches. Therefore the square nut was the very best form then to make.

But after a time, as beauty of form is demanded, the uncouth proportions of the square nut are noticed, and its superfluous, projecting corners are rejected, and the hexagonal form usurps its place. The metal which is useless in the square nut is added to the sides of the hexagonal, and with this more equal distribution a much stronger nut is obtained with the same weight of metal, as the weak places of the square nut are the spaces midway between the corners or angles. The greater number of angles the nearer the nut approaches to a circle, and of course attains a greater strength; then why may we not discard the angles altogether and form the nuts either round or cylindrical! A few years ago we had no wrenches to turn such a shaped nut, but now mechanical ingenuity has given us a score or more of tools adapted to this very end, which tools are in constant use for operating upon round rods and pipes, and certainly they will be as effectual in turning a cylindrical nut as in turning a gas-pipe. The greater strength of the cylindrical form would seem to favor its adoption, and it can be finished so as to present as neat an appearance as the hexagonal form of nut.

But with the adoption of the hexagonal form, new means must be brought into requisition for their ready manufacture, and the punch and die, in connection with the power press is employed, and the product of nuts is so much cheapened that it is useless for the blacksmith with forge and anvil to contend with it, as the press will form a hundred nuts of better form and shape than the single one made by the smith in the same amount of time.

We see, then, how the business of nut manufacture can be made a specialty, and how, by the manufacturer devoting his time and capital to it, a better article can be produced at a cheaper rate than that first formed by manual labor.

BOLT-HEADS AND NUTS.

WITH the adoption of the hexagonal form of bolt-head and a nut of corresponding shape began the era of beauty in the form of these necessary portions of the bolt. While the square form of head and nut was in vogue, probably no portion of any mechanical appliance received at the hands of the makers such indefinite and varying proportions. In those days the smith or other mechanic made the bolts as they were required, and, cutting off an indefinite length of iron, he measured the length of bolt, and then fashioned the head from the excess over the required length. Instead of the thickness of the head being nearly that of the bolt, we notice that it was sometimes one-half and even less that thickness, and the nuts fitted to these bolts were of similar varying proportions.

That there exists a relationship between the tensile strength of the bolt and the thickness and diameter of the head, all mechanics will admit, and in this relationship the forms of beauty must also exist. A round bolt-head has a beauty of form greater than that of the square one ; but as a difficulty exists in turning the round form of head or nut with any of the wrenches now in use, the nearest approach to the circle which obviates this difficulty, viz., the hexagonal form, has been adopted, as combining all that is essential as regards both strength and beauty.

Prior to the introduction of the improved wrenches now presented for service, the square head or nut was needed to enable it to be turned with the rude appliances used for that purpose not many years ago. With better made wrenches, which were adjustable yet unyielding in their application, a less angle of the bolt-head or nut was required, and the hexagonal form was adopted, and with this form comes a system as regards their diameter and thickness which good mechanics observe, yet many seem disposed to wholly ignore.

We will take the quarter-inch bolt, as a bolt of this diameter of body is designated, and the thickness of nut and head made of hexangonal form should both be the same as the said diameter, and the width over the sides three-eighths of an inch. A half-inch bolt should have its nut of the same thickness as its body; but its head may be a little thinner, say about one-sixteenth, and the width over sides three-quarters of an inch. With the exception of the thickness of the head, it should have twice the measurement of the quarter-inch bolt-head and nut. The three-quarter inch bolt should have three times the measurement of the quarter-inch, and the inch bolt four times those measurements, except in the thickness of the heads, which may be diminished relatively as the sizes increase. The intermediate sizes vary somewhat from these, accordingly as they increase or decrease. It may be received as a rule that the width of a nut, when measured over the sides, should be one-half more than the diameter of the bolt.

The following table may be taken as a sufficiently correct guide for all practical purposes by those who would make hexagonal bolt-heads and nuts of a uniform size, and of proportions to correspond to the tensile strength of the bolt:—

Diameter of bolt in inches.	Width of nut over sides.	Thickness of head.	Thickness of nut.
$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{4}$
$\frac{5}{16}$	$\frac{9}{16}$	$\frac{5}{16}$	$\frac{5}{16}$
$\frac{3}{8}$	$\frac{9}{16}$	$\frac{5}{16}$	$\frac{3}{8}$
$\frac{7}{16}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{7}{16}$
$\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{16}$	$\frac{1}{2}$
$\frac{9}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{9}{16}$
$\frac{5}{8}$	1	$\frac{1}{2}$	$\frac{5}{8}$
$\frac{3}{4}$	$1\frac{3}{16}$	$\frac{5}{8}$	$\frac{3}{4}$
$\frac{7}{8}$	$1\frac{5}{16}$	$\frac{3}{4}$	$\frac{7}{8}$
1	$1\frac{1}{2}$	$\frac{7}{8}$	1
$1\frac{1}{4}$	$1\frac{7}{8}$	1	$1\frac{1}{2}$
$1\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{1}{8}$	$1\frac{1}{2}$
$1\frac{3}{4}$	$2\frac{5}{8}$	$1\frac{3}{8}$	$1\frac{3}{4}$
2	3	$1\frac{5}{8}$	2

DIPPING ACID FOR BRASS.

THERE are various methods of finishing brass, as by turning and polishing in the lathe, finishing with the file and burnisher, or covering with a coat of colored lacquer, or immersing it in a bath of acid. Oftentimes portion of brass which we wish to ornament cannot be finished in the lathe or will not pay the cost of hand-finishing; we may cast such portions of the required form at once, and then produce a beautiful surface most ingeniously and cheaply by immersing it in a bath of "dipping acid." This bath is made by mixing together nitric acid, sulphuric acid, and muriate of ammonia or sal-ammoniac. The work, if it has been in contact with oil or grease, may be heated to consume such grease, and it will then be dis colored and dirty; it must be pickled in a bath of diluted nitric acid, which may be one part acid to three or four water. The articles must not be permitted to remain too long in the pickle, as injury will result by the acid eating holes in the work; to clean the surface of the metal is all that is required. Remove the articles from the pickle and wash them clean, so as to alike remove any adhering dirt and the acid in which it has been immersed. The dipping bath is composed mostly of nitric acid, the sulphuric acid and the muriate of ammonia being present in inferior quantities. There is no certain rule by which to mix them. Much depends on the concentrated character of the acids. A little experience will enable the operator to judge for himself of the proportions he needs. Strong nitric acid alone will do, but many prefer to add a quantity of the other ingredients. The mixture should be so strong that a momentary immersion will be sufficient to make the work bright and clear, no matter how rough it may have been. Remove the work from the bath and immediately plunge it in clean cold water and wash it well to remove the acid, and give it a final and thorough washing in hot water. If a little crude tartar be added to the hot water it will more effectually remove the acid. To dry the work it may be embedded in fine hot saw-dust.

The surface produced is beautiful and may be protected with a coat of clear varnish or lacquer, but without the lacquer the surface will be retained for a long time and withstand considerable wear and handling.

PRESERVATION OF METALLIC SURFACES.

THE great tendency of sheet-iron to decay by oxydation has led to the employment of many methods of preventing it. The first and most natural of these seems to be a coating of some substance, and paint or oleaginous varnish has been much employed. This is often employed where the exposure of the natural color of the iron is of no account, or where there is no desire to conceal the material of which the work to be preserved is made. Asphaltum and black varnishes are largely employed in many places, and a surface thus protected is susceptible of being gilded and elaborately finished, after the manner of the small signs, tea-waiters, coffee cans, etc., we so often see. Coating the sheet metal by immersion in a bath of melted tin is adopted, and it is the most common and perhaps the best protection that sheet-iron can have. A familiar illustration is the numerous articles of household use that are so very common. There is a process called galvanizing (but the term is not correctly applied, as the process is not completed by the galvanic current) that is common in some places.

It consists in coating the iron by immersion in melted zinc, after the manner of coating the iron with tin. Articles of cast or malleable iron that are exposed to damp or are used when immersed in water are coated in this way with beneficial results. An example is seen in the iron fixtures of dairy churns, family washing machines, wringers, etc. There is also a process of enameling that has been somewhat used; the article is dipped in a gummy fluid and the gloss or enamel, reduced by pulverization or grinding to a granulous powder, is dusted upon the gummy surface, where it adheres; the article is then put into a muffle and placed in a furnace, and after a few minutes' ex posure to the heat the powder fuses into a uniform glossy coating, affording a good protection to the article so covered. The enamel kettles and stewpans used by the housewife for boiling and cooking acid fruits are made after this process. It is capable of a more extended application than has been made of it. To coat the sheets of iron with either the tin, zinc, or enamel, it is immersed in sulphuric or muriatic acid for a sufficient time to clean them of the scale of oxyd by which they are covered; they are then carefully washed clean, dipped in a solution of muriate of zinc, and then immersed in a bath of tin or zinc, a thin coating of which immediately adheres to the surface.

By means of the electro-deposit process sheet metal may be coated with gold, silver, or copper, but this process is used most upon articles of ornament and is intended to hide the metal of which they are formed. As the process is quite cheap when but a light coating of the metal is employed, it is extensively used, the material of which the articles are made being principally sheet-brass or of soft metal.

MOTHER-OF-PEARL.

MOTHER-OF-PEARL is the inner coat or layer of several kinds of oyster shells, some of which secrete this layer of sufficient thickness to render the shell an object of manufacture. The beautiful tints of the layer depend upon its structure, the surface being covered with a multitude of minute grooves, which decompose and reflect the light. These grooves are often so minute that more than three thousand of them are contained in an inch.

The lammelar structure of the pearl shell admits of its being split into laminæ, and it can then be used for the handles of knives, for inlaying, the manufacture of buttons, etc.; but as splitting is liable to injure or spoil the shell, this method of dividing it is seldom resorted to. In manufacture the different parts are selected of a thickness as nearly as possible to suit the required purpose, and this excess of thickness is got rid of by means of saws, filing, or by grinding upon the common grind-stone. In preparing the rough shell, if square or angular pieces are needed, they are cut with saws, as the circular saw or the ordinary back saw; in the one case, the shell is fed up as the saw divides it, and in the other the shell is held in a vise, and the saw operated by hand. If circular pieces of the shell are wanted, such as those for buttons, etc., they are cut with an annular or crown saw, which is fixed upon a mandrel. It is necessary in sawing that water be plentifully supplied to the instrument, or the heat generated by dividing the shell will heat the saw, and its temper will be destroyed. The pieces of shell are next ground flat upon a grindstone, the edge of which is turned with a number of grooves or ridges, as being less liable to become clogged than the entire surface, and hence grind more quickly. It is necessary that water be supplied to the stone, but if soap and water be employed, the stone is less liable to become clogged. The flat side of the stone, similarly prepared with ridges, may be used instead of the face, if it be desired to have the pieces of shell ground flat, and when of the requisite thinness they are ready for operation in the lathe, for inlaying, etc.

After the pieces of pearl shell are cut, ground, or turned to the proper form, they are finished with pumice-stone and water; this may be done with pieces of the stone properly shaped, and rubbed over the work as it is held fast in some form of clamp, or held upon the work as it is revolved in the lathe. This process may be followed by an application of ground pumice-stone, which has been carefully sifted to extract all except the minutely powdered portion, and applied with a piece of cork or a cloth moistened with water. The polishing is accomplished with rotten-stone, moistened with dilute sulphuric acid, which may be applied upon a piece of cork or a bit of soft wood. The acid tends to develop finely the striated structure of the shell. In some turned works fine emery paper may be used, and followed with rotten-stone moistened with the acid, or some limpid oil instead.

The pearl handles used for razors or knives are first roughed out, then drilled where the rivets are to be inserted, and then lightly riveted together in pairs. They are then ground to the proper size and thickness, and finished by the means mentioned. The last finishing touch, to produce a fine polish, often being done by the friction of the hand of the workman.

Sometimes it is advantageous to apply the polishing material to the surface of a wheel, and this wheel may be covered with cloth and moistened with water, which will cause enough of the powder to adhere. Separate wheels may be used for the pumice-stone and the rotten-stone. Sometimes dry powdered chalk or Spanish whiting is used in place of the rotten-stone.

One process of working pearl is similar to that of engraving in metals in relief, by the aid of corrosive acids and the etching point. The shell is first divided as may be necessary, and the designs or patterns drawn upon it with an opaque varnish;

strong nitric acid is then brushed over the plates repeatedly, until the parts untouched or undefended by the varnish are sufficiently corroded or eaten away by the acid. The varnish now being washed off, the device, which the acid has not touched, is found to be nicely executed. If the design is to be after the manner of common etching on copper, the process upon the shell is precisely the same as that process upon metal.

When a considerable number of pieces of thin shell are required to be of the same size and pattern, the requisite number of plates are cemented together with glue, and the device or figure drawn upon the outer plate. They may then be held in a vise or clamp, and cut out as one plate with a fine saw, or wrought into the desired form with files; drilling tools may be employed to assist in the operation. To separate the pieces, the cemented shells are thrown into warm water, which softens the glue and separates the pieces.

PEARL INLAYING.

THE manufacture of pearl-inlaid or japanned articles is now quite common. A few years ago articles of this description were wholly imported from China to France and England, and then again imported to the United States, where they were sold at exorbitant prices. The prices at which these articles are now sold is so reasonable as to be within the reach of every one, and every common laborer can deck his little cottage with a beautiful clock inlaid or ornamented, or furnish his wife with a tea-tray or work-box of the same description.

Cast and sheet iron and papier-mache are the materials upon which pearl is generally inlaid. The process is as follows:—If the article be of cast-iron, it is well cleaned from the sand which usually adheres to the casting, and is blackened with a coat of varnish and lamp-black. When this is thoroughly dried, a coat of japan or black varnish is spread evenly upon it. Before the varnish becomes too dry, pieces of pearl cut in the form of leaves, roses, or such flowers as the fancy of the artist may dictate, or the character of the article may require, are laid upon the varnish, and pressed down with the finger, and they immediately adhere to the varnished surface. The work is then placed in a heated oven and kept there for several hours, or until the varnish is perfectly dried. It is then taken from the oven and another coat of varnish applied indiscriminately on the surface of the pearl and the previous coating, and again placed in the oven till dry. This process is repeated several times. The varnish is then scraped off the pearl with a knife, and the surface of pearl and the varnish around it is found to be quite even. The pearl is then polished with a piece of pumice stone and water, and the surface of the varnish is rubbed smooth with powdered pumice stone, moistened with water.

It is in this unfinished state that the pearl has the appearance of being inlaid, and from which it derives its name. Its final beauty and finish depends altogether on the skill of the artist who now receives it. Under his hands, the shapeless and almost unmeaning pieces of pearl are made to assume beautiful flowers, leaves, etc. The artist traces the stems and leaves of the flowers with a camel's hair pencil, dipped in a size made of varnish and turpentine ; upon this he lays gold leaf, which adheres where there is size, and the superfluous gold is carefully brushed off with a piece of silk. The flowers and leaves are then painted in colors, and when dry the picture and surface of the article is covered with a coat of refined white varnish.

The kinds of pearl used are three :—mother-of-pearl or the pearl oyster, or white pearl, as it is called by the artist, and it is known by its clear white surface ; aurora shell, which can readily be told by its wrinkled appearance and its various prismatic colors, and is made from the shell of the genus of mollusca known as the sea-ear or ear-shell, and known to the conchologist as haliotis ; the green snail shell, which can be told by its glistening colors of light and dark green, a soft yellow, and a bright and beautiful pink, blended together.

To manufacture the pearl ready for inlaying, the workman cuts the rough shells in pieces with saws and then grinds the pieces upon both sides upon a common grindstone until they are of the requisite thinness. Out of these pieces the artist cuts the forms of leaves, flowers, etc., with a pair of common scissors preparatory to placing them on the varnished surface. The necessary forms may be cut from the thin pieces of pearl by means of a punch and dies with power applied by the foot of the operator. When a number of pieces are required to be of the same size the pieces may be fastened together with glue as one solid plate, and then the required form marked upon the outside one, then these being held in a vise the form can be carefully sawed out with a fine saw ; by placing the cemented pieces in warm water the glue softens and the shells are easily separated and the glue washed off.

This art of inlaying is not confined to the representations of flowers alone; landscapes with houses, castles, trees, churches, and bridges are very easily made, and when represented as being seen by moonlight are very beautiful. The rising moon can be represented surrounded by clouds of gold and silver bronze, and when pieces of pearl are placed in certain positions to reflect their colors, the moonbeams are represented as glancing over the landscape in alternate light and shadow.

A varnished surface can be ornamented by transferring drawings or engravings to it and the process is quite simple. A thin coat of copal varnish is spread upon the surface of the article, and when nearly dry the engraving is applied with its face downward and carefully pressed to exclude all air-bubbles. When the varnish is sufficiently dry the paper is thoroughly moistened with a sponge dipped in warm water and the paper can be rubbed off, leaving all the lines of the print upon the varnished surface.

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